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**Problem-Based Learning embedded within a Research-Based
Framework for teaching: A qualitative study of preservice
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**Problem-Based Learning embedded within a Research-Based
Framework for teaching: A qualitative study of preservice teachers'
conceptions of teaching and learning**

by

Andrea Jean Madsen

A thesis submitted to the graduate faculty
In partial fulfillment of the requirements for the degree of
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This is to certify that the master's thesis of
Andrea Jean Madsen
has met the thesis requirements of Iowa State University

Signatures have been redacted for privacy

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Chapter 1. Introduction

Rationale

Since 1955, and the launch of the Soviet *Sputnik*, there has been continuous dialogue in the United States on how to improve science education. Much research has been done to move the teaching and learning of science forward, but little has changed in the classroom. Researchers even say school science is in a crisis, and studies done on the current state of education would support this statement entirely (Goodlad, 1983; The National Commission on Excellence in Education, 1983; Schmidt, et al., 1998; Yager & Penick, 1983). “The goal in science education has more often been devising and implementing a ‘new’ curriculum rather than devising appropriate instructional strategies and methodologies” even though many “teachers lack the philosophical underpinning, psychological bases, or civic rigor” required to produce students who are active, critical thinkers, problem-solvers, and life-long learners (Ponder & Kelly, 1997, p. 244; Gottfried & Kyle, 1992, p. 46). After nearly fifty years of supposed reform, it is clear that simply teacher proofing the curriculum or focusing on quick-fix solutions is not the best way to solve our problems (Wallace & Louden, 1992). More attention needs to focus on how to create exceptional teachers because it not curriculum or policy makers, but teachers who make excellent science programs (Penick, Yager, & Bonnstetter, 1986; Wallace & Louden, 1992). Robert Fullan (1996) captured the essence of the problem currently facing educators when he wrote,

I believe that one of the main reasons that teachers seem to be constantly defending themselves from external critics is that they cannot explain themselves adequately. Critics are increasingly using clear language and specific examples in their charges, while educators are responding with philosophical rationales (e.g., we are engaged in active learning). Abstract responses to specific complaints are not credible. What does it mean to say that educators cannot explain themselves adequately? Perhaps teachers do not fully understand what they are doing, or perhaps they are simply unable to articulate it. (p. 423)

It is time that teacher education programs focused on what can be done to ensure that their teachers are prepared to teach in a manner different from the way they were taught. This implies that they can make conscientious decisions based on professional knowledge of

research and in turn articulate this in a manner that is intelligible and credible to a skeptical public.

Research Questions

Teacher education programs need evidence that what they are doing in methods courses and pre-service programs is effective for promoting the conceptual change needed to create effective teachers who make decisions based on research and professional knowledge. The development of an RBF in a science methods class “promotes coherent pedagogical decision-making that reflects the best available knowledge base for advancing effective teaching” (Clough & Kauffman, 1999, p. 527). A review of the current research shows that many science educators are advocating the use of a Research-Based Framework (RBF) in secondary science methods courses (Clough & Berg, 1997; Penick, 1988). Little has been documented about the effectiveness of the RBF for producing exceptional elementary science teachers (Veronesi & Lambert, 1999). Research done by Veronesi and Lambert (1999) and Veronesi and Varrella (1999) show that first year elementary teachers, as well as pre-service elementary teachers perceive that a science rationale does impact them and their teaching in a positive way. Both of these studies focused on self-reported perceptions about the RBF. This study seeks to more fully understand the impact the RBF and oral defense have on pre-service teachers’ practice and thinking while student teaching. This study seeks to go beyond self-perception and critically analyze what pre-service elementary teachers write, say and do in order to create a profile of the understandings demonstrated and articulated for each study participant.

Other educational research advocates the use of Problem-Based Learning (PBL) as a way to have pre-service teachers connect what they are learning in methods courses to the real world of teaching. Further studies are needed to show the effect of PBL on pre-service teachers’ connections between content knowledge, pedagogical knowledge and real classroom situations. Research is also needed to show the impact PBL has on pre-service and/or in-service teaching. No documented research can be found describing a PBL experience embedded within an RBF-driven classroom. This study seeks to more fully understand the impact the RBF has on pre-service professional development and the impact a

PBL situation has when used within the framework of a RBF classroom. Specifically, this study seeks to answer two questions:

1. What differences, if any, can be seen at the end of the science methods course between preservice teachers who had an RBF science methods course and those who experienced a PBL situation embedded within the RBF science methods course?
2. What differences, if any, can be seen during student teaching between student teachers who had an RBF science methods course and those who experienced a PBL situation embedded within the RBF science methods course?

Organization of This Study

This qualitative study examined two classes of science methods students who each received equivalent instruction by the same instructor. The only difference between the two groups of students is that one received a PBL experience, while the other completed a traditional unit plan assignment. Both groups developed an RBF and orally defended it at the end of the course. Samples from the two classes were paired; one student from class A was paired with one student from class B based on ACT and college GPA scores. This study consists of four paired samples. A thorough description of each participant's thoughts about teaching and learning during science methods class and thoughts and actions during student teaching is included. The findings are presented, followed by recommendations for future research in this area of study.

Chapter 2. Literature Review

A Research-Based Framework for Science Teaching

In order to promote the use of educational research by pre-service teachers to drive their classroom decision-making and to help them articulate clearly these classroom actions, many teacher education programs are using a research-based framework (RBF) or rationale in their science methods course. The idea of a science rationale was originally developed by Schlitt, and has been widely implemented across the United States, largely as a result of its use by Penick at the University of Iowa. Some of the original literature described the rationale as a

conceptualization and integration of all of the following: (1) teacher, student and societal goals for science education; (2) why science should be taught; (3) what science must be learned; (4) the nature of science; (5) how to facilitate learning in science in a manner consistent with what is known about adolescents, learning and science; (6) the nature of adolescents; and (7) how to personally assess, evaluate and change classroom climates and strategies to achieve progress toward stated goals. (Krajcik, Pencik, & Yager, 1986, p. 2)

The RBF has been more thoroughly described by Clough (1992) and Clough and Kauffman (1999). Literature also describes implementation of the RBF into science methods courses and student teaching (Clough, 2000; Dass, 1999; Veronesi & Lambert, 1999; Veronesi & Varrella, 1999).

Teachers Have Goals

Goals are an important aspect of the research-based framework. When asked what their goals are for K-12 science education, both preservice and inservice teachers come up with strikingly similar lists (Clough & Berg, 1995; Penick, 1986; Penick & Bonnstetter, 1989).

They want students to:

- Be creative and curious,
- Use critical thinking skills,
- Identify and solve problems effectively,
- Use communication and cooperative skills effectively,
- Demonstrate a deep understanding of science concepts,

- Convey an understanding of the nature of science,
- Know how to learn,
- Apply their knowledge, and
- Convey self-confidence and a positive self-image.

Yet, many teachers only promote the learning of science concepts in their classrooms; typically the science taught tends to be based on facts rather than big conceptual ideas (Goodlad, 1983). Many teachers teach the way they were taught, and when asked about their pre-service program, many will admit they learned the most in student teaching. Teachers may want to promote lofty goals in their classroom, but it is rare to find a teacher who can articulate how to achieve their goals unless they have been explicitly directed to it (Penick & Bonnsetter, 1989). The RBF explicitly attends teachers to their goals and forces them to think about the pedagogical decisions that will help their students reach the goals.

Teachers Use Research

Another central aspect of the RBF is that research is required to justify the decisions made in the classroom. Clough (1992) claims that the RBF is what “separates the professional science teacher from those who simply have a strong science background” (p. 37). Links between research and pedagogical decision-making should help teachers explore, conceptualize and defend their practice (Calderhead, 1993). Note that reading research in and of itself is not useful. Teachers must know how to use the research they read so they continually grow in their teaching abilities. The pre-service teacher who is writing an RBF must take his or her goals through a schematic (see Appendix A for the schematic). In the RBF it is the links (or arrows) that are crucial to a pre-service teacher’s understanding of teaching. Good teaching is a complex activity. It requires an extensive and well-organized professional knowledge base of how children learn and what that implies for how adults should best teach them. For the professional teacher, how children learn and where they are in their learning affects the teacher behaviors displayed and the science content, materials and activities used. The teaching behaviors and content, materials, and activities should lead students to perform actions that demonstrate they are meeting the teacher’s predetermined goals for the lesson or unit.

The idea of a professional teacher using educational theory to drive daily, practical decisions in the classroom is not new; knowledge of how children best learn is what the Dewey School in Chicago was founded upon. In essence, the school was a laboratory used for testing the theory upon which it was based. Mayhew and Edwards (1936) admit that many of the early problems the school faced were the direct result of an insufficient focus on the underlying aims and principles that influenced the day-to-day decisions made by the teachers and other staff. This implies that the school did a better job of educating students when the primary focus was on how theory and research could be effectively implemented in the practical daily decisions of the classroom teachers.

Characteristics of Effective Teachers

In the RBF, students write a thorough description of what research indicates they should be doing as a teacher. Research shows that teachers who enter the classroom without a clear picture of themselves as teachers are doomed to flounder, and may suffer frustrations great enough to have them choose a different occupation (Kagan, 1992). By having pre-service teachers write an RBF they should have a clearer idea of what it takes to become an excellent science teacher. Penick and Yager (1993) along with Clough and Berg (1995) list characteristics of exemplary science teachers. They claim teachers should:

- Provide a stimulating and accepting environment,
- Have high expectations of themselves and their students,
- Challenge students beyond ordinary tasks,
- Be models of inquiry,
- Want students to apply knowledge,
- Start with the students' prior knowledge and cognitive development,
- Use instructional practices that indicate the above differences play a central role in pedagogical decisions,
- Expect different students to achieve differently,
- Expect learning to occur over a period of time as opposed to a daily dose of information,
- Provide a hands-on and minds-on science experience,
- Avoid textbook or lecture centered instruction,
- Facilitate many student goals, recognizing that the single goal of content acquisition is, by itself, an empty goal,
- Remain extremely flexible in their time, schedules, and curriculum expectations,

- Require considerable student self-assessment,
- Ask questions, expecting to hear new and often unpredicted answers,
- Recognize that learning occurs through student activity,
- View science content as something more than knowledge that simply exists for student mastery,
- Expect students to question knowledge, teachers, and authority in a respectful manner,
- Focus on problems, questions, and unknowns,
- Not view classrooms as boundaries,
- Frequently focus on societal issues involving science,
- Not force closure.

These teacher characteristics are not easy to acquire. It takes a deep understanding of theory, critically self-assessed practice, and a passion for learning and teaching to become a good science teacher. The RBF serves as a model for effective teaching. When pre-service teachers go out into schools and teach, they can then compare what they know is good teaching to what they actually do; therefore, the RBF should help teachers self-assess their lessons, units, and science programs (Penick, 1988). Teachers who fail to self-assess and rely on others for an evaluation of their teaching are “captives of their own inabilities.” (Penick, 1988, p. 4). Effective teachers constantly self-assess their lessons and seek out new information in order to develop better skills, deeper knowledge, and more effective science programs.

Learning Through the Research-Based Framework

The RBF is much more than a final project turned in at the end of a methods course. It serves as the overlying framework for the entire semester. Dass (1999) argues that the entire teacher education program should be designed around the rationales. Other research indicates that an RBF can be utilized in a single science methods course and that the entire course can be devoted to discussing components of the rationale (Veronesi, & Lambert, 1999; Veronesi & Varrella, 1999). This particular study utilized the RBF throughout an entire semester.

Conceptual Change of Preservice Teachers

In the science methods class, the goal of the instructor is to move students forward in their thinking about teaching and learning so they can become effective elementary teachers. This requires students to undergo some form of conceptual change; dissatisfaction, intelligibility, plausibility, and fruitfulness are four conditions needed for conceptual change (Posner, Strike, Hewson & Gertzog, 1982). Without dissatisfaction, and the accompanying negotiation of new ideas with prior ideas, “knowledge acquired during pre-service teacher education appears to be superficial.” (Kagan, 1992, p. 147)

Students enter the class with memories of themselves as students in a science classroom, images of themselves as a teacher, and ideas about what teaching and learning should be. Generally, students enter the course satisfied with their understandings of teaching and learning. Because of this student satisfaction, activities and content are deliberately used in the course to challenge students’ perceptions and understandings. Throughout the course there is a constant ebb and flow of discomfort and comfort, dissatisfaction and satisfaction; this is needed so students feel comfortable enough to take the risk to learn.

Students initially create a list of their past science experiences, reflect upon them and discuss how their past experiences are different than the ideal state of science teaching. Then, students create student goals and as the semester goes on, they learn about teaching behaviors, learning theory, and content, materials and activities that help them more readily achieve their goals, but they still have to conceptualize how all the pieces fit together to form an effective teaching package. After the first five weeks of methods class, the students begin a four-week practicum experience. Instead of attending methods class, they go out into elementary schools two days a week. After the practicum experience, the students come back to the university and attend class until the end of the semester. Anxiety usually creeps back up because they now realize that they are not as effective as they would like to be. Throughout the semester, different students reach the different conditions at different times, depending upon their conceptual understanding. It is hoped that the majority of students will undergo the conceptual change needed for them to become an effective teacher.

The Influence of Social Learning Theory

Students spend much of the semester making meaning about teaching and learning in groups and as a class. While the act of writing the RBF is an individual one, much of the meaning for the students is shaped by the class activities and social interactions (Rowell, 1997). The central idea of social learning theory is that meaning is made through group interactions and this group knowledge influences what students come to know individually. Rivard and Straw have shown that the combination of talking in groups and writing individually can enhance the positive effects of both strategies (Rivard & Straw, 1996; in Mason, 1998). Sharing ideas and making social meaning for concepts is also congruent with constructivism and conceptual change (Mason, 1998; Henriques, 1997).

The Impact of Writing on Learning

The written RBF at the end of the course is crucial for each individual student to organize ideas, clarify thoughts, connect new knowledge to previous knowledge, reflect upon the learning and construct new knowledge (Galbraith, 1999; Klein, 1999; Mason, 1998; Rivard, 1994). Writing is a permanent record of what students think. Once thoughts are on paper, students have the opportunity to revisit their ideas, and revise them as they see fit. Revision in this case is more than just correcting grammar and spelling. It is revising the conceptual links between ideas and fitting knowledge together in a manner that makes more sense to the writer. Studies have shown that students who frequently reviewed their texts made more conceptual gains during writing than those who did not (Klein, 1999). The knowledge-constituting model proposed by Galbraith (1999), argues that writing creates new knowledge and new connections especially when existing content does not satisfy the goals of the writer. E.M. Forster is widely quoted as saying, "How do I know what I think, until I see what I say?" An implication of this is that as we write, we discover more about what we think.

The RBF is not an easy paper to write; it requires much time and effort to write one that is truly a reflection of what the student thinks. Students who do not take the assignment as seriously as hoped will flounder in the oral defense because they have difficulties

articulating what they want to do in the classroom, or more importantly why they are doing it. Students who take the assignment seriously will go back and visit their paper after methods class is over. The paper may become part of their professional portfolio. For them the RBF will truly serve as a tool for continued growth and learning as they become a teacher.

Problem-Based Learning

Why Use Problem-Based Learning?

A major problem that many teacher education programs face is the issue of how to get pre-service teachers to put the theory they learn in classes into practice during their practicum, student teaching, and professional teaching experiences. Griffin (1999) wrote that new teachers commonly believe their student teaching experiences far outweigh their teacher education courses in importance for them to become effective educators. This statement appalls teacher educators because it demonstrates that students do not realize the importance of what they are learning in their undergraduate courses and more importantly how their undergraduate courses are critical for becoming effective teachers. Many a teacher educator will grumble that pre-service teachers just want to know how to teach. These students reduce teaching to the lowest common denominator (activities and strategies) and fail to see the relevance of educational learning theories, history, philosophies or the teacher's role (Dean, 1999). These students need a way to connect all of their pre-service learning together into a coherent whole so they can accurately think about the complex nature of teaching and learning. Griffin (1999) also stated that

if we expect teachers to be thoughtful about their practice, we should provide opportunities for guided practice to be informed by theory and theory to be tested against guided practice. If we expect teachers to be constantly inquiring into the nature and consequences of their work, we should provide individual and group opportunities to ask serious questions about practice and search for answers in practice as well as in theory. (p. 13)

Griffin is arguing that educational practice and educational theory are equally important and that effective educators can use both successfully. In order for students to base their

educational practice in educational theory and see the relevance of doing so, teacher education programs should “reveal pedagogical problems” and provide opportunities for students to think about these problems and practice solving them (Carter, 1990). Supporters of problem-based learning believe that knowing how to do something is just as important as knowing content and vice versa (Estes, 1999). The integration of the two is critical for solving problems and using knowledge appropriately.

Problem-Based Learning (PBL) was originally designed in the 1960’s for use in medical schools so that students would have the opportunity to place what they were learning into a context of a real-world medical problem (Shoemaker, 1960; Schmidt, 1965; Barrows, 2000). PBL now has widespread use in many areas such as undergraduate chemical education (Ram, 1999); undergraduate biology education (Mierson & Parikh, 2000); K-12 education (Schmidt & Moust, 1998; Stepien & Gallagher, 1993; West, 1992); educational administration (Estes, 1999); and teacher education (Dean, 1999; McDonald, 2001; Peterson & Treagust, 1998; Pierce & Lange, 2001) to name a few. PBL started in medical education because it promotes skills that are critical for physicians to make decisions that do not fit the clear-cut textbook examples they learned in school. Physicians must learn to adapt their factual knowledge to fit many different contexts and problems. This is very similar to the situations facing teachers. Teachers must be able to use their professional knowledge, often in diverse conditions and under stress and time limits, to make professional decisions that affect students’ minds, self-esteem and lives. It is imperative that they can apply to their teaching the theories, strategies, and ideas that they should learn in their pre-service program. PBL should fit in nicely with teacher education courses because the “primary motivation for teachers’ learning emerges from classroom problems” (Wallace & Loudon, 1992). In an ever-changing world, the benefit is great when one knows how to successfully identify and solve many problems, rather than relying on knowing a limited amount of specific solutions in order to solve specific problems.

Elements of Problem-Based Learning

Finding the right problem is a challenge in PBL because the choice of the problem determines the probability of student success in learning through PBL. In order for PBL to

work effectively, the problem must be chosen with great care and should be compelling, authentic, based in real-world experiences, ill-structured in order to generate multiple hypotheses, require creative and critical thinking skills, and require knowledge and skills that meet curricular objectives (Ram, 1999; Stepien & Gallagher, 1993). Students should not have all the information they need to solve the problem nor know the specific actions needed to solve the problem; this forces students to work through the problem, search for connections to what they already know, search for new information to fill in their knowledge gaps, wrestle with the complexity of the problem and ultimately use their knowledge to fabricate a solution; for the desired learning takes place through the work students do to understand the problem and then resolve it (Peterson & Treagust, 1998; Stepien & Gallagher, 1993).

Students work cooperatively in small groups in order to solve the problem. Depending on the problem, students could assume different roles, each having a real stake in the problem at hand (Stepien & Gallagher, 1993). Some teachers structure the PBL so it is an in-class activity, while others make the students responsible for the problem outside of class. This depends on the nature of the students, the nature of the course, the teachers' preference, and the time available. Regardless of where the students carry out the work, PBL experiences usually require a significant amount of time to complete. The nature of the PBL experience demands that teachers use authentic assessments; this promotes creativity in the way teachers assess their students (West, 1992).

The teacher's role during a PBL experience is that of a tutor or coach. He/she needs to be available to answer questions students may have and, depending on the age and developmental level of the students, be prepared to help lead them in the appropriate direction if they get side tracked. The teacher must give the students the freedom to learn on their own and take ownership of the problem, for PBL is a student-directed and student-centered activity.

The Effect of Problem-Based Situations on Learning

Through Problem-Based Learning students learn to identify what they need to know, gather information, work with others, evaluate ideas based on research, self-assess, take on

responsibility, become self-directed, and design solutions (Stepien & Gallagher, 1993). PBL has spread to so many diverse situations because the skills needed to successfully work in teams to solve problems are the same skills many institutions want their students or employees to possess. PBL promotes critical thinking, information acquisition skills, problem-solving skills, cooperative group work, oral and written communication, life-long learning, responsibility, scientific thinking, organizational skills, and the connection of school knowledge to real life (Levin, 2000; Ram, 1999).

Research conducted on the effectiveness of the PBL approach has been positive. When comparing students who used PBL and those who did not, researchers found no statistical differences between the two groups' factual knowledge as demonstrated on test scores (Verhoeven et al., 1998). This indicates that students learn as much factual content knowledge using the PBL approach as they do using more traditional approaches. Norman and Schmidt (1992) suggest that PBL can increase "the transfer of concepts to new problems," intensify student interest in the subject matter, and strengthen students' study skills (in Hughes, 1999, p. 432). This implies that students who use the PBL approach may increase the connections of content to practical, real-life situations. Dods (1997) suggests that students are more motivated to identify and explore what they don't know when the content is presented in the context of a problem. In one study, which specifically addressed learning to teach primary science using a PBL approach, the authors stated that the participants reported that they used science content and pedagogical knowledge together when resolving a problem (Peterson & Treagust, 1998).

Conclusions

This study embeds problem-based learning within the context of an elementary science methods class that is driven by a research-based framework for teaching science. The RBF is theoretical and uses theory and research to influence potential classroom decisions. PBL is rooted in more practical, real-world situations. The problem used in this study gave students a context with which to think about the connections and complexities of teaching and relate them to the RBF schematic. The research presented in the literature review indicates that both PBL and an RBF, when used in isolation, have positive influences

on pre-service teachers' conceptions of teaching and learning. This study seeks to determine the effect PBL has, when embedded in an RBF classroom, on pre-service teachers' knowledge of the complexities of teaching and learning as they transition from students to student teachers.

Chapter 3. Methodology

Description of the Science Methods Course

At the beginning of the semester, students described the current state of science education and the ultimate desired state of science education. Then they created a class list of student goals and student actions that demonstrate attainment of the goal. These goals served as a reference point for the rest of the semester. As the semester progressed, different elements of effective teaching were discussed, along with how they connect with what we know about how students learn.

After five weeks of class, students in Class A, working in groups of two, turned in a five-lesson unit plan for science (See Appendix B for the student handout). The lessons could be written for any elementary grade level. The methods students were not given a specific classroom context with which to base their lessons. The unit requires students to demonstrate their understandings of learning theory, the role of the teacher, and their goals as well as use appropriate lesson planning models.

Students in Class B had the unit plan assignment modified; they were given a 40-minute videotape of an elementary teacher teaching science and were asked to analyze the teaching as a group of three followed by the development of two lessons. One lesson replaced the lesson on tape; the second lesson would be conducted the following day. Both classes of students were required to address the same conceptual elements in both assignments. Class A worked in groups of two, class B worked in groups of three; this difference was assumed to be negligible. The critical difference between classes A and B was the real classroom context on the PBL videotape that was given to Class B. The lesson on the videotape gave the pre-service students a context with which to critique and evaluate a science lesson using everything they had learned about teaching so far in their education program. On the surface, the lesson appeared to be effective because the students were well behaved, the teacher had very good behavior management skills, and science content was being promoted through a hands-on cooperative group activity. Delving deeper into the lesson, however, revealed that the science content was too advanced for the developmental

level of the elementary students involved and the activity was purely hands-on while requiring little thinking on the part of the students. The teacher-student interactions were extremely teacher-centered and teacher-directed. This required students to go past merely identifying strengths and weaknesses of the lesson, to demonstrating that they could generate solutions to the problems identified and design a science lesson that would be better suited for the classroom observed on the videotape (For more information about this assignment, see Appendix C). This assignment was considered to be a problem-based learning experience as the challenge to analyze the tape was ill-structured, students lacked all the necessary information to analyze the tape, and group negotiation was required. Both classes received extensive feedback on the assignments.

Following this assignment, all students completed a four week practicum experience, teaching in schools in place of attending classes. While out in the field, they audio-taped themselves interacting with students. They then analyzed and self-assessed their interaction patterns with students. Extensive feedback was given, but no letter grade was placed on the paper. This forced students to critically self-assess, rather than relying on the instructor to “give” them a grade.

Students in both groups then had the remaining five weeks in class to put all the pieces together. Individual goals were assigned to collaborative groups; each goal was placed in the context of the schematic in Appendix A. They presented their goal, the research that supports it, and how they would promote that goal while teaching. They received feedback from their classmates as well as the professor on where their presentation of the goal could be strengthened. They were also asked questions similar to those they would face in the oral defense at the end of the semester.

The Research-Based Framework paper was due at the end of the semester. In the paper, the students needed to support the goals they had for their students with research. They then needed to take each goal through the RBF schematic showing student actions, teacher behaviors, content, materials, and activities that would help them reach their goals. Students also needed to show that their decisions were based on educational research.

A critical component of the RBF process is that students orally defend their thinking and their teaching practices. Students were each scheduled for a 1.5 hour oral defense the

last two weeks of the semester. Questions were designed to assess the depth of knowledge students possess about teaching and learning and the extent to which they could articulate their decisions about how they would teach their students. In the oral defense, students self-assessed their performance in the course based on grade criteria established by the instructor, and supported with evidence (see Appendix D for the criteria). Self-assessment was consistently emphasized throughout the course because if pre-service teachers do not learn how to self-assess themselves while in school, it is doubtful they will learn how to while teaching (Dass, 1999).

Description of the Two Classes and the Selected Participant Samples

Sample from Class A

During the spring semester, Class A completed an elementary science methods course that utilized the Research-Based Framework for teaching during the entire length of the course. This class completed a set of five consecutive science lesson plans (done in pairs), self-analyzed interactions with students, wrote a research-based paper for teaching, and orally defended what they understood about teaching and learning along with defending a grade for the course. Four students were randomly chosen to participate in this study based on the following criteria: (1) they agreed to participate and signed a consent form, and (2) they were student teaching during the consecutive fall semester in a school district close to the university so that observations and interviews would be time and cost feasible.

Sample from Class B

During the fall semester, Class B completed an elementary science methods course that utilized the Research-Based Framework for teaching during the entire length of the course. This class completed the PBL analysis of a videotape of teaching (done in groups of three) and then provided two lesson plans based on the context of the videotape (done individually), self-analyzed interactions with students, wrote a research-based paper for teaching, and orally defended what they understood about teaching and learning along with

defending a grade for the course. Four students were chosen to participate in this study based on the following criteria: (1) they agreed to participate and signed a consent form, (2) they were student teaching during the consecutive spring semester in a school district close to the university so that observations and interviews would be time and cost feasible, and (3) their ACT score and college cumulative GPA very closely matched one of the participants from the class A sample so a paired sample could be obtained. Purposeful sample selection is a key component when using qualitative methods to do educational research (Glesne, 1999). In this study, a paired sample was desirable so that comparisons between class A and class B could be made.

Description of Participants

All eight participants, four from class A and four from class B, were white, Midwestern females in their early twenties, classified as seniors in their final year at a traditional four-year university. The following table describes the ACT and GPA scores of the participants. Each student was assigned a letter that corresponds with further data tables throughout this text. Student A was paired with student E; student B was paired with student F and so on. Pseudonyms have been used for all participants.

Table 1. Description of participants' GPA and ACT scores.

Class A				Class B			
	Student Name	GPA	ACT		Student Name	GPA	ACT
A	Allison	2.87	25	E	Evelyn	2.90	24
B	Barb	3.52	26	F	Faye	3.37	26
C	Cassie	3.6	20	G	Grace	3.35	20
D	Denise	3.12	21	H	Holly	3.18	21

Data Collection and Analysis

Data Collected from Science Methods Course

Research-Based Framework Papers. Due to the qualitative nature of this study, data consists of descriptions and analysis relies on coding procedures in order to find essential pieces of teaching and the ways the participants organize, think, and link the pieces of teaching together (Glesne, 1999). The RBF papers of all participants were copied and coded according to the elements and links found on the RBF schematic. Citations referring to the RBF paper contain the capital letter, P, followed by the page number(s) where the quote was taken from. The coding scheme used in this study was modified from an RBF coding scheme designed by Clough, Numedahl and Olson (2001). (See Appendix E for the coding scheme). Components of the schematic were coded as absent, low, moderate or high based on their congruence with the predetermined criteria of the coding scheme. Specific components analyzed were 1) level of interactions between student goals, 2) quality and frequency of teacher behaviors and strategies, 3) quality and frequency of statements made connecting the selection of content, materials and activities to student goals, 4) quality of connections between learning theories and teacher behaviors and strategies, 5) quality of connections between learning theories and content, materials, and activities, and 6) understanding of self-assessment.

Oral Defense. All oral defenses were audio-taped for course grading purposes. Citations referring to the oral defense conversation contain the capital letters, OD, followed by the counter number where the quote started. Many questions were asked of students during the oral-defense; five questions were asked of all students. These five questions and the students' responses were transcribed and coded for all study participants (See Appendix F for the questions and their codes according to Olson, 2002). Using the data from Olson (2002), as well as listening to the tapes, each participant's responses were coded according to criteria very similar to the RBF paper. Components of the schematic were coded as absent, low, moderate or high based on their congruence with the predetermined criteria of the coding scheme (See Appendix G for oral defense coding scheme). Specific components

analyzed were 1) level of interactions between student goals, 2) quality of teacher behaviors and strategies, 3) quality of statements made regarding the selection of content, materials and activities to promote student goals, 4) quality of connections between learning theories and their influence on teacher behaviors and strategies, 5) quality of connections between learning theories and content, materials, and activities, and 6) understanding of self-assessment.

College GPA and ACT Scores. Participants' college accumulative grade point averages and ACT scores were collected and used to select the paired samples used in the study. In addition, this information was used to ensure equivalency between the two classes so comparisons could be made. Sawyer and Maxey (1981) found the American College Testing Program (ACT) to be a significant predictor of student achievement. Even though the ACT test "may not measure all of the knowledge and skills required for performance success in college," it is highly probable that it measures most of the "important or necessary skills and knowledge required in college courses" (Paszczyk, 1994, p. 5). College grade point averages are dependent upon many variables such as students' work ethic, class participation, class performance and aptitude. The combination of the two scores enabled paired samples to be chosen with greater confidence than a single measure alone.

Data Collected During Student Teaching

Observation of Student Teaching Practices. During the participants' student teaching experience, one 30-45 minute observation was made of them teaching a lesson. Attempts were made to observe a science lesson, but for two participants this was not possible. One could argue that the nature of science instruction is inherently different than the nature of language or social studies instruction; therefore the richness of these data may be limited. However, the elements of effective instruction found in the RBF schematic, such as good teaching behaviors, learning theory, and teaching towards big goals, would be useful regardless of the subject matter taught. These elements of instruction are not science specific so one would expect to see evidence of them in other subject lessons as well. The observer took notes, paying close attention to any evidence of RBF elements or links evident during

the lesson. The notes were typed, with each line of the document given a number. Citations referring to observation notes contain a capital letter O, followed by the line number from the typed notes.

Components of the observed lesson were coded as absent, low, moderate or high based on their congruence with the predetermined criteria of the coding scheme (See Appendix H for observation coding scheme). The classroom criteria are inherently different than the RBF, oral defense, or interview coding criteria because the data is observed, not written or articulated, but ultimately the overall coding scheme is consistent with the other three coding criteria.

Specific components analyzed were 1) number of goals promoted as evidenced through student actions observed, 2) amount of effective teacher behaviors and strategies observed, 3) quality of content, materials and activities that would elicit the student goals written by the student in their RBF paper, 4) effective use and reflection of learning theories observable in the student teachers' behaviors and strategies, and 5) effective use and reflection of learning theories observable in the content, materials, and activities.

Interview. After the observation, a short interview was conducted with each student teacher. Each interview was audio-recorded and transcribed, with each line in the transcription having a number. Citations from the interviews refer to the interview by a capital letter (I) and the specific line number(s) from which the quote was taken. The interview questions focused on goals for students and how the student teacher would help students meet the goals, how student teachers felt about teaching elementary science, and what student teachers thought about the RBF and oral defense and how the process affected their thinking and teaching (see Appendix I for the questions).

Components of the schematic were coded as absent, low, moderate or high based on their congruence with the predetermined criteria of the coding scheme (See Appendix J for the interview coding scheme). The criteria developed for the interview was very similar to the criteria used during the oral defense and RBF paper. Specific components analyzed were 1) level of interactions between student goals, 2) quality of teacher behaviors and strategies stated, 3) quality of statements made connecting the selection of content, materials and

activities to student goals, 4) quality of connections between learning theories and teacher behaviors and strategies, and 5) quality of connections between learning theories and content, materials, and activities, and 6) understanding of self-assessment.

Comparison Methodologies

Each of the four data sources of this study were coded in order to describe specific components of the pre-service teachers' understandings as absent, low, moderate, or high. Through these descriptions a profile of each student was made. The student profiles were developed according to the four major data sources: RBF, oral defense, classroom observation, and interview. This enables the researcher to track students' understanding from a theoretical pre-service experience (RBF paper), to an application of that knowledge (oral defense), to the practical implementation of their knowledge (student teaching). Rich descriptions of the students are included to show the extent of the students' understandings and how and when those understandings changed, if at all.

The profile of each student based on the RBF and oral defense was then compared with her profile during the student teaching semester. Strengths, weaknesses, and changes for each student were identified to determine: (1) what elements of the RBF remain with the student during student teaching and inform their practice, (2) what elements of the RBF do not transfer to student teaching, and (3) whether students who had the PBL experience transfer more of their RBF understandings than those who did not have this experience.

It is important to note the two parts of the data collection (methods class and student teaching), were done by two different researchers. The methods instructor collected the RBF papers and conducted the oral interviews. The author of this paper observed the student teachers' lessons and conducted the interviews. The researcher who observed the lessons and conducted the interviews had no prior knowledge of the students' understandings; therefore those observations could be made with less bias. This adds credibility to the study and makes possible a more objective comparison between what students thought and articulated during science methods class and what they demonstrated, thought and articulated during the student teaching experience. Due to this method of data analysis and the fact the two semesters were taught by the same instructor using the same instructional methods,

comparisons between the two semesters of science methods students could be made with increased confidence.

The qualitative findings of this study will be used to extend research conducted by Olson (2002); the study reported here involves participants from the same two classes of students. While the Olson study investigated statistical differences between the non-PBL group and PBL group's understandings on the oral defense, it fails to provide rich descriptions of how specific student understandings change or important information about the impact that problem-based learning had on pre-service teachers' actions and thoughts while student teaching, if any.

Chapter 4. Findings

An important component of the science methods course and the RBF is having a strong understanding of the elements of the schematic and understanding how each element informs the others. If individual pieces are not linked with the rest of the framework, then the teacher is not using elements of effective instruction. An effective teacher should have a deep understanding of all the pieces and how they inform each other. In the following section, participants' understandings of teaching are described. Four participants from class A, Allison, Barb, Cassie and Denise are described first; then the four participants from class B, Evelyn, Faye, Grace, and Holly. Particular attention is given to how each student teacher is using each element of teaching found on the RBF schematic. First, the understandings at the end of science methods, as evident through the RBF paper are described. The knowledge written in the RBF is theoretical and can be written using notes and other sources to help make connections. Second, the understandings that students articulate during the oral defense are described. The knowledge elicited by the oral defense describes what students think when faced with novel situations in teaching. Third, the lesson observed is described and used to show tacit understandings of the student teacher. This describes what the student teacher actually does in the classroom. Finally, the understandings of each student teacher, made explicit through the interview, are described. These articulations describe what the student teacher understands about their own teaching in a very personal and concrete context. Tables providing brief outlines of students' understandings, exemplified by the written RBF, oral defense, observations and the interview, are provided for each student teacher, along with a thorough description of the lesson they were observed teaching during their student teaching experience.

Sample Participants From Class A

Student A: Allison

The lesson observed during Allison's student teaching experience was part of a unit on balance and motion in a second grade classroom. The lesson began with students sitting

in a circle on the floor participating in a class discussion reviewing the previous science lesson. They discussed the ways cups roll down ramps. Allison gave students directions and told them the challenge questions for the day: “See if you can get the cup to park under the ramp. See if you can get the cup to roll straight down the ramp.” Students then worked to solve these questions in cooperative groups of 3-4 students. When a group made a discovery, a student would put their arm in the air and yell, “Give me five!” The other students would stop their work and listen to what the group found out. At the end of the lesson, groups cleaned up their work area and returned to the big circle on the floor. The class then discussed the discoveries they had made and what they had learned. Some of the student comments during this time were: “Never say that you can’t do something, just try.” “There are at least twenty ways to roll your cup down the ramp.” “Do not blurt out when someone is sharing what they discovered.” The students were not sharing science ideas, but Allison did not probe their ideas to reach this end.

During the lesson, students explained how they put cups together, discussed with others how the cups rolled down the ramp, tried out ideas, worked collaboratively to solve challenge questions, listened to other’s ideas, answered teacher questions, and shared what they had learned. Students also cleaned up after themselves, volunteered consequences for misbehavior, and showed much excitement and enthusiasm during the entire science lesson. These student actions demonstrate that the goals promoted by the lesson, as stated in Allison’s RBF paper, were 1) Use positive communication skills, 2) Develop problem solving skills and strategies, 3) Actively participate cooperatively and individually, 4) Be a good citizen, 5) Meet/exceed the district’s curriculum standards for that grade level, and 6) Develop and use cooperative skills in various setting and with a variety of people. The researcher assumes the lesson met a district standard because Allison indicated that the lesson came from a Full Option Science System (FOSS) kit. A district probably would not spend the money for a kit if it did not meet a standard for that grade.

Goals. As shown in Table 2, Allison failed to mention the interactions between her goals in both her RBF paper and oral defense. In her paper, the goals were listed in a linear fashion; during the defense they were stated briefly. The lesson Allison taught during her

student teaching experience promoted several goals simultaneously; consequently, her tacit understanding of goals was coded as high. During the student teaching interview, when asked what her goals were for the lesson observed, Allison replied, “the same goal that the district uses, just experiencing it and getting the feel for it.” (I, 7) She went on to say that the goal was “basically to be exposed” to the activities (I, 9). She did not mention any other goals during the interview so this link is coded as absent.

Allison did not articulate interactions between her goals during science methods; she did not articulate her goals at all during student teaching. The lesson observed elicited several student goals, but Allison was not aware of them and they certainly were not her focus.

Table 2. Allison’s understandings of goals and their interactions.

RBF Paper	Oral Defense	Class Observation	Interview
Absent	Absent	High	Absent

Content, Materials and Activities. In the RBF paper, Allison’s writing conveyed a low understanding of activities that would promote her student goals. She missed several opportunities to discuss activities and in a few instances made connections such as, “A wonderful way to set goals is to have students brainstorm a topic by writing in their journals everything they know about that topic or concept.” (P, 12) Other activities she listed in her paper included: KWL (What you know, what you want to know, what you learned) charts, map reading, presentations and writing activities. The content and materials that Allison would use to reach her goals were missing from her paper; therefore they are coded as absent in Table 3.

The focus of Allison’s oral defense was the activities she would select for her students. She discussed them and gave several specific examples, but did not articulate explicit connections describing how they would promote her goals. Allison also articulated content and materials she would use with her students, but did not describe them to the depth she discussed her activities. Overall, Allison articulated a low understanding of how her content, materials and activities connect to her student goals.

The content, materials and activities Allison used during the observed lesson promoted several goals simultaneously; this link was coded as high. Allison's lesson plan indicated that her two objectives for the students during the lesson were behavioral. She wanted them to 1) "be able to observe and experiment with the way cups roll down the ramp" and 2) "be able to observe and experiment with the way cups roll down the ramp when weight is added to the cups." (I, 107-111) The evidence that students were meeting her goal was "their discoveries. They discover the ways that the cups move and roll." (I, 12-13) Allison was able to articulate very clearly a high link between the content, materials and activities selected and the student actions and goals that she wished to promote.

Allison's articulation of content, materials and activities and their links to her goals or student actions became stronger during student teaching. This could be attributable to experience and thoughtful practice. Usually teachers know and can articulate what content, materials and/or activities they will use and what students should be doing as a result of those activities. Allison's objectives were behavioral, so she didn't have to say very much to show she knew what components of her lesson promoted her desired objectives. Her articulation was high because her only goal was that of her behavioral objectives. Allison did not articulate how her content, materials or activities promoted any other goals.

Table 3. Allison's understandings of content, materials and activities and their connections to student actions and student goals.

RBF Paper	Oral Defense	Class Observation	Interview
Activities—Low Content—Absent Materials—Absent	Low for all 3	High for all 3	High for all 3

Teacher Behaviors and Strategies. Allison conveyed low understandings of both her teaching behaviors and strategies; in her RBF paper they are mentioned with low quality and low frequency. She mentions a few teaching strategies such as modeling, demonstrating and giving rewards but does not connect these strategies to her student actions or goals. She also articulates her behavior. Her role was to "move around the classroom and ask the students

thinking questions.” (P, 4) She also used “nonverbal communication such as nodding, eye contact...facial expressions, gestures, posture and wait time.” (P, 4) At one point in the paper, she wrote, “teachers need to use appropriate wait time, verbal and nonverbal communications to keep students on task.” (P, 7) Unfortunately, she only linked her behavior to classroom management, not the facilitation of student goals.

During the oral defense, Allison also articulated a low understanding of her teaching behaviors and strategies. She mentioned the behavior of questioning without assistance. When asked specifically what her role was in a class discussion, Allison described several behaviors that would be classified as nonverbal behavior, such as facial expression, eyebrows, nodding, gestures, and posture. However, she missed several other opportunities to discuss her teacher behaviors and strategies during the oral defense.

During the observed lesson, Allison demonstrated a moderate use of teacher behaviors. She had excellent wait time and patience. She would wait until all students were settled and ready to listen before she asked a question or gave directions. Her nonverbal communication conveyed that she was interested in what the students were doing and what they had to say. Allison asked the following questions during the lesson:

“What did we do yesterday?”

“If people are horsing around, what should the consequences be?”

“Has anybody made any discoveries yet?” “Any others?”

“Why do you think it does that?”

“How might you do that?”

“What discoveries have you made today?”

“What did you notice about it?”

“Have we worked with anything else that rolls?”

“What have you learned?”

After each question, Allison would wait for many students to raise their hands. Then she would call upon one student at a time. Many of the questions she asked required students to think and her behaviors elicited many student ideas. Many times Allison did not respond to what students said. She simply listened and waited for another student to share his/her idea. This was evident during the large group discussions. Students would share ideas, but she

would not probe further into their comments. This caused the lesson to focus on discovering the way cups move and roll rather than using the lesson to get to the ideas of balance and motion, which were the big themes of the unit. Allison has an excellent start on her teaching behaviors; but they are not quite a succinct package yet due to her lack of student-centered responses.

Even though Allison demonstrated some effective teacher behaviors and strategies, afterwards when asked what her role in the classroom was, Allison responded, “just watching them to make sure they’re staying on task with what they’re doing and not eating the cups or anything like that. Just helping them experiment with it.” (I, 16-18) Later in the interview she commented that “the easiest [was] questioning.” (I, 30) She stated that the “nice little typed form of grading yourself on questioning” from science methods class has “helped a lot.” (I, 31) Even though she brought up questioning, she did not articulate why questioning is important or what it is used for. At best her link from teacher behaviors to student actions is low.

As shown in Table 4, Allison’s articulations of her teaching behaviors did not change from science methods class to student teaching. Her observed teacher behaviors are stronger than her articulated ones; therefore, Allison may not be able to manipulate her teaching behaviors to elicit the student actions she wants. In order to manipulate elements of a lesson, a teacher needs to be able to consciously identify what they are doing and why it is not working. The only component of teaching behaviors that remained with Allison while student teaching was that of questioning. Unfortunately, she does not articulate the importance of this behavior.

Table 4. Allison’s understandings of effective teacher behaviors and strategies.

RBF Paper	Oral Defense	Class Observation	Interview
Low	Low	Moderate	Low

Learning Theory and its connection to Content, Materials and Activities. In the RBF paper, Allison only used two learning theories to help her select her content, materials and activities. On page 5 she wrote, “If students do not know how to effectively communicate

what they know to the teacher, the teacher may not choose appropriate content, materials and activities for the class.” She also wrote, “teachers will have to find out what students do know and build off that knowledge. This can be done through KWL charts, prewriting activities and questioning.” (P, 7) On page 11 she wrote, “The social learning theory supports students participating in their education because the students will be learning from their peers.” Overall, her connections to constructivism and her use of social learning theory conveyed low understandings because they were incomplete.

During the oral defense, she also articulated a low understanding of how to use learning theory to select her content, materials and activities. When given a specific context, she was able to articulate a link to developmental learning theory. She also mentioned social and constructivist learning theories at a low level because her statements were either inaccurate or incomplete.

Even though Allison expressed low understandings at the end of methods class, the content, materials and activities she used during her lesson were moderately influenced by developmental, social and constructivist learning theories. All aspects of the lesson were developmentally appropriate for 2nd grade. The students used common, everyday materials and worked together in small groups to solve a very concrete problem. Students actively worked with the materials, but more importantly they also thought about what they were doing and were able to share with others their thoughts. In many respects, students were left to come to the science ideas on their own. This is most likely a result of the content she planned to teach. The content, materials, and activities that Allison selected were moderately influenced by behavioral learning theory. Allison’s objectives, which were written in her lesson plan, were behavioral: (1) Students will be able to observe and experiment with the way cups roll down the ramp, (2) Students will be able to observe and experiment with the way cups roll down the ramp when weight is added to the cups. Through the implementation of her lesson, the students were able to meet her objectives and demonstrate the behavior she was looking for. It was observed, however that this behavior was not the only thing Allison wanted; many other goals for students were promoted through the lesson.

During the interview, Allison explicitly stated that she hadn’t “actually thought about the theories that would be involved.” (I, 51) She did not perceive herself using learning

theories to make decisions about her teaching behaviors or the content, materials and activities in a lesson. She commented that, “when [the RBF] talks about you need to have...philosophies to back you up, I haven’t used any yet.” (I, 49) She perceived that educational philosophies and learning theories are used to defend practice, but not used to make decisions in the classroom. These comments imply she was not deliberately using learning theory to select her content, materials and activities or influence her teaching behaviors so the links between these components are absent, as shown in Table 5.

Table 5. Allison’s understandings of learning theories and their connections to content, materials, and activities.

	RBF Paper	Oral Defense	Class Observation	Interview
Behaviorism	Absent	Absent	Moderate	Absent
Constructivism	Low	Low	Moderate	Absent
Social	Low	Low	Moderate	Absent
Developmental	Absent	Low	Moderate	Absent

Learning Theory and its connections to Teacher Behaviors and Strategies. In her RBF paper, Allison used two learning theories to influence her choice of teaching behaviors and strategies. Consistent with her selection of content, materials and activities, her use of constructivism, as it influences her behaviors, demonstrated a low understanding. On page 9 she wrote, “Using open-ended questions will allow students to use their problem solving skills as well as allow the teacher to find out what students know about the content being covered.” Twice in her paper she wrote, “The social learning theory supports students participating in their education because the students will be learning from their peers and the modeling that the teachers are doing.” (P, 11) Overall her use of social learning theory also demonstrated a low understanding.

As shown in Table 6, Allison also articulated low understandings of learning theory in her oral defense. She stated that all students learn differently so multiple strategies are needed in order for every student to learn in the classroom. She also mentioned that questioning is beneficial because it causes students to think more deeply about the content.

Allison did not articulate any other links to learning theory, so this particular connection is coded as low.

The behaviors Allison used during the lesson were highly consistent with developmental, social and constructivist learning theories. Allison's teaching behaviors required students to share their ideas with others. Allison did not tell students what they were supposed to do exactly and she gave them great freedom in the ways they went about solving her challenge questions. While students were working, she asked groups a few probing questions to get them to think about what they were doing, however she did not respond to student comments in a manner that would elicit more student thinking or explicitly promote the learning of balance and motion. Allison's behaviors demonstrate that she did use behavioral learning theory, but only for classroom management so it was coded as absent. She told students, "You may go to your communities, discuss what you are going to work on today. Material managers can get the materials after the group has decided on what you are going to need. You can do anything, just don't cut the cups." Students then left the circle in a loud, unruly fashion, so she brought them back and dismissed them in small groups of 3-4 students.

As a student teacher, Allison articulated a very low understanding of teaching and learning. She stated, "I haven't needed to [use the RBF]" (I, 62) and "I'm not really defending what I'm doing right now...I'm doing it because I think its good." (I, 75-76) This articulation implies that she perceives the RBF process as useful only if a teacher is required to defend her/his teaching practices. When asked if she used ideas from her RBF while student teaching, her response was, "I'm not sure." (I, 58) She also said she was "having a hard time remembering it." (I, 70)

Overall, Allison's articulations of learning theory went from low to absent. She has the misconception that learning theories are used to defend teaching practices to skeptics, rather than used to influence and guide teaching practices. She made the comment during the interview that she does things because she thinks they are good. She based her decisions on opinion rather than research.

Table 6. Allison's understandings of learning theory and its connections to her teacher behaviors and strategies.

	RBF Paper	Oral Defense	Class Observation	Interview
Behaviorism	Absent	Absent	Absent	Absent
Constructivism	Low	Low	High	Absent
Social	Low	Absent	High	Absent
Developmental	Absent	Low	High	Absent

Self-Evaluation. In her RBF paper, Allison described a moderate understanding of how to evaluate herself and her program. On page 4 she wrote, "The teacher should also videotape lessons and review them to make sure that he or she is accurately demonstrating these strategies." During the oral defense, Allison stated that she would ask any colleague or administrator to observe her teaching in order to determine her success in the classroom. This articulation demonstrates a low understanding of self-assessment. During the interview, Allison stated how the SATIC (Schlitt-Abraham Teacher Interaction Coefficient) coding sheet was useful; unfortunately, she did not elaborate upon this or describe if she was currently using such a tool to improve her teaching practices (Abraham & Schlitt, 1973). Overall, Allison's level of evaluation of herself and her teaching went from moderate, to low, to absent, as shown in Table 7. Allison has no explicit sense of how to improve her practice, nor does she have an explicit sense of how to determine if she is successful in the classroom.

Table 7. Allison's understandings of how she will determine if she is a successful teacher.

RBF Paper	Oral Defense	Class Observation	Interview
Moderate	Low	Not Available	Absent

Summary of Allison's Understandings. Allison's strengths are demonstrated by her high to moderate level of tacit understandings as observed during student teaching. Overall, she demonstrated fairly effective teaching behaviors and strategies, planned an inquiry-based lesson that was developmentally appropriate and met several of the goals she had listed in her

RBF paper. Her lesson demonstrated several of the concepts the science methods course intended for students to learn.

Overwhelmingly, her weakness lies in her relative inability to articulate what she tacitly understands. During the methods course her articulations were low at best; months later while student teaching her explicit understandings had weakened. Specifically, her explicit understandings of goals, learning theory, and self-evaluation dropped off to nothing.

Student B: Barb

The lesson observed during Barb's student teaching experience was part of a unit on oceans in a fourth grade classroom. The lesson began with students sitting at their desks, which were arranged in rows facing the front of the classroom. The beginning of the lesson focused on what the students knew and what they had learned from the previous science lesson. The previous lesson had the students put an egg into a container that held salt water and then place an egg in a container that held fresh water. The students perceived that the lesson was about eggs, rather than what Barb intended, which was a lesson about the differences between salt and fresh water. Barb articulated to the observer this discrepancy and her confusion as to what to do about it. She mentioned that she sought help from her science methods instructor as to what could be done to change the students' ideas.

The lesson observed consisted of a class discussion reviewing the previous day's activity and relating what was observed to the term estuary. At the end of the lesson, students divided up into their science groups, obtained their materials, and made observations. Each group had a cup of water placed inside a closed Ziploc baggie that had a permanent home on a windowsill. The baggie and its contents represented the earth's atmosphere and demonstrated the water cycle. The students discussed their observations in their groups.

During the lesson, students listened to Barb and to other students, volunteered their ideas and thoughts, made observations, discussed with group members, and showed respect for themselves and others. These student actions demonstrate that the goals promoted by this lesson, as stated in Barb's RBF paper, were 1) Understand the content, 2) Work

cooperatively, 3) Use higher order and critical thinking skills, 4) Become life-long learners, and 5) Experience personal and social growth.

Goals. Barb did not address the interaction of goals in her RBF paper or during her oral defense. She simply listed them separately and explained them in a very linear and disconnected fashion; therefore, the interactions are coded as absent as shown in Table 8. During the oral defense, she discussed what she would do to facilitate the learning of content in her classroom, but did not link that to any of her other goals.

The number of goals promoted by Barb's lesson implies that her implicit understanding of goal connectedness is moderate. After the lesson, Barb articulated a low understanding of her goals. When asked what her goals were for her students, Barb replied, "I wanted them to get the big concepts. I didn't care if they didn't know the vocabulary words; I just wanted them to have some understanding of the concept." (I, 7-9) Later she stated, "my goal [is] to have them talk it out and figure it out." (I, 25) She also mentioned, "I want students to think about their answers, instead of just guessing." (I, 169-170)

Barb did not articulate interactions between her goals during science methods; she did articulate a few of her goals during student teaching, but again failed to articulate the connections between those goals. The lesson observed promoted some student goals, three that Barb was able to articulate. Even though her explicit understandings of goals is low, her focus during the lesson on the big idea or big concept of the lesson is a good place to start (National Research Council, 1996).

Table 8. Barb's understandings of student goals and their interactions.

RBF Paper	Oral Defense	Class Observation	Interview
Absent	Absent	Moderate	Low

Content, Materials and Activities. In the RBF paper, Barb wrote a low understanding of the links from materials and content to her goals because she seldom mentioned them and rarely linked them to student actions or goals. She mentioned "manipulatives" (P, 6) and "newspapers." (P, 15) She did write that, "newspapers can supply problem-solving

opportunities,” but this was the only link she had (P, 15). Barb sparingly wrote about the content to be used to facilitate her goals. She wrote “the content should single individuals out based on their contributions” but failed to link it to her goal of multiculturalism (P, 21). Barb focused on activities throughout her paper and generally had high links between them and her goals. One example of her link from content to goals is, “After some practice in cooperative groups,...the teacher will provide the students with hands-on problem-solving activities so that they will learn together by communicating, sharing ideas and materials, taking on responsibilities, listening to each other and completing the assigned task.” (P, 8)

During the oral defense, Barb mentioned many activities that would facilitate her goals, but missed several opportunities to explicitly link her content, materials and activities to her student goals. She responded to the questions, “How would you decide what (content to teach, materials to use with, or activities to use with) your students?” at a low level of understanding.

Barb demonstrated higher tacit understandings of these connections during her student teaching experience. The content, materials and activities she selected promoted a moderate number of her student goals. After the lesson, Barb articulated a moderate link between the selection of content, materials and activities and her student actions and student goals for the lesson. She “wanted them to write in their science logs, but” they ran out of time (I, 19). She wanted the students to “talk it out and figure it out.” (I, 25) She commented that her students “ask questions that are tough. That’s why [she] said [they] could email somebody.” (I, 33) She felt that a difficult aspect of teaching science was “finding activities...[that] match the thing they need to learn.” (I, 43-44)

Barb’s articulations about content, materials and activities and their links to her goals or student actions remained about the same between the course and student teaching, as shown in Table 9. She focused more heavily on activities than she did on content or materials. Barb’s focus was on the big idea; she knew her students did not understand her big idea, so she had to change plans and rethink how she was going to teach for that concept attainment.

Table 9. Barb's understandings of content, materials and activities and their connections to her student actions and student goals.

RBF Paper	Oral Defense	Class Observation	Interview
Content—Low Materials—Low Activities—High	Low for all 3	Moderate for all 3	Moderate for all 3

Teacher Behaviors and Strategies. In her RBF paper, Barb had a moderate understanding of both her teaching behaviors and teaching strategies. Barb mentioned several effective teacher behaviors, but did not connect them to all of her goals. She wrote that “asking higher order thinking questions encourages lifelong learning” (P, 18) and “teachers must also allow for appropriate wait time after posing these questions. The students must be able to hash the questions out on their own.” (P, 18) Barb also wrote that the teacher “must put his/herself at the students’ level. When students make eye contact towards the teacher looking for support, the teacher must look away to other students in the classroom. This nonverbal signal will direct the student back to his/her peers in order to reach an acceptable solution. These teacher behaviors will make students go beyond factual knowledge and think more critically about issues.” (P, 12) She mentioned responding patterns by writing, “when an answer is given, the teacher should ask for elaboration or clarification from the student when necessary. This puts the thinking back on the students and allows them to explain or justify their solutions or opinions.” (P, 11) Barb also wrote about several teaching strategies, some of which were, to “show enthusiasm,...be energetic, speak positively...and smile.” (P, 4) She said that a teacher should “encourage” (P, 4) students, “plan well-rounded groups,” (P, 8) “observe” (P, 8) and “incorporate humor.” (P, 18) Usually Barb stated her strategies; rarely did she connect her teaching strategies to a goal. One accurate connection she made in her paper was, “Teachers must model effective problem-solving skills to the students. This can be done by brainstorming solutions to a given problem out loud, weighing the benefits and consequences of the different solutions, and deciding on the best solution. This will give the students an example to follow when they are faced with a problem.” (P, 14)

During the oral defense, Barb articulated a low understanding of how her role in the classroom influenced her student goals and actions. After one probing question, she mentioned teacher questioning, after nine probing questions, she mentioned the use of nonverbal behaviors. She never mentioned wait time or responding patterns during the oral defense. Her focus of the oral defense was on what her students were to be doing, not what she would do to get them there.

During the observed lesson, Barb exhibited a moderate use of effective teacher behaviors. She demonstrated good wait time one, conveyed interest and enthusiasm through non-verbal communication, asked a variety of questions and elicited more than one student response for many of the questions asked. The following is list of some of her questions:

“Would we bring eggs to a lake? An ocean?”

“Why would I have you put eggs in water?”

“What would float in the ocean? What would sink in the ocean?”

“What would float in a lake? What would sink in a lake?”

“What happens when freshwater meets saltwater?”

After a student suggested they would mix together, Barb asked,

“How would it mix together?”

Barb then introduced the term, estuary. She asked the students, “What animals would live in an estuary?” The students mentioned salmon and gave their reasoning for thinking of that idea. Barb then had the students think about the state of Iowa and asked questions that led to a class discussion concerning temperature changes during the different seasons and what different animals do in order to survive. After this discussion, she asked questions relating the temperature differences in Iowa to the salt differences in the water of an estuary. The students then suggested ways an animal might survive the salt differences in an estuary. During the small group work, Barb circulated to different groups and asked questions to probe their understanding. Barb used her teaching behaviors effectively most of the time; however, improvement is needed to use them as a coherent whole. Rarely did she respond to students without repeating their comments or praising.

After the lesson, when asked what evidence she had that students were meeting her goal, Barb responded, “Just asking questions.” (I, 18) She articulated her role as, “asking

them questions, trying to get them to talk it out ... on their own.” (I, 22) She also commented that she should “just be the guide.” (I, 25-26) Through the RBF process, Barb “realize[d] the teacher isn’t the person who stands up and lectures, it’s the person who asks the questions and who get the kids thinking.” (I, 61-63) All of these articulations demonstrate that Barb has a moderate explicit understanding of her role in the classroom and how it affects her students.

As shown in Table 10, Barb’s articulations about her teaching behaviors did not change from science methods class to student teaching. Her observed teacher behaviors are about the same as her articulated ones.

Table 10. Barb’s understandings of effective teacher behaviors and strategies.

RBF Paper	Oral Defense	Class Observation	Interview
Moderate	Low	Moderate	Moderate

Learning Theory and its connections to Content, Materials and Activities. Barb used three learning theories to help her select her content, materials, and activities. First, she wrote, “the teacher must also know the level of cognitive development within his/her students. By using this information, the teacher will know what types of experiments and how in depth to get with them before the students can grasp the concept.” (P, 4) On page 6, she wrote, “Most elementary students are either at the concrete or formal levels. These levels suggest the type of manipulatives, if any, need to be provided by the teacher. Students at the concrete level are unable to think in abstract terms. This means it is vital to their understanding that they are given hands-on manipulatives to experiment with and use.” Her link from developmental learning theory to content, materials and activities is low because her understanding seems to be incomplete. She does not mention that concrete thinkers need concrete concepts, as well as hands-on manipulatives.

In her paper, Barb used constructivism at a high level to select her content, materials, and activities. Barb wrote, “The teacher must first implement activities that get at students’ prior knowledge.” (P, 12) On page 5, she explained how “whole group discussion can reveal vital information about a student’s prior knowledge and experience.” She also mentioned

writing and KWL charts as other means to elicit student prior knowledge. She frequently wrote statements like, “small group activities, email, the internet, letters, whole and small group discussions, experiments, and historical research...will influence the students’ thinking and affect their prior knowledge.” (P, 22) She also wrote, that experimentation would be useful to challenge prior knowledge that “is not accurate.” (P, 7)

Barb also used social learning theory at a high level to select her content, materials, and activities. She wrote, “Problem-solving activities directly relate to the social learning theory. Students are working together to explore a problem and discussing possible solutions. They are evaluating their ideas and the ideas of others in order to make the most educated and informed decision. The students are learning by watching others, influencing others, and being influenced by others.” (P, 16)

During the oral defense, Barb had a low understanding of how learning theory could be used to select her content, materials and activities. Barb only used learning theory when probed explicitly to address how learning theory would apply to the situation. Her references to learning theory demonstrated a low understanding of both developmental and constructivist learning theories, despite the strong mention of them in her paper. She did not make references to the behavioral or social learning theories.

The content, materials and activities used during the observed lesson were moderately influenced by developmental, social, and constructivist learning theories. The previous lesson dealt with the concept of density, which is developmentally inappropriate for most 4th graders. Barb dealt with this issue by bringing in the concept of an estuary and leading students to a better idea of what the activity was actually about. The materials used and activities employed were developmentally appropriate. The class discussion and group work utilized student ideas and helped them make connections between the ocean, water and animal life. Students were actively sharing their ideas. The lesson attempted to have students think about and understand the material, rather than just memorize facts. The lesson reflected behaviorism minimally. Students were in rows, had to raise their hands, were reminded to listen to others, and had roles during their group work.

Consistent with her oral defense, during the student teaching interview, Barb articulated a low understanding of how to use learning theory to select her content, materials

and activities. She indirectly referred to constructivism when she commented on how hard it is to “[make] the learning fall on the shoulders of the students.” (I, 48) She articulated the need to “[make] them think about it and [keep] their attention while they think about it.” (I, 49-50) In order to do this she says, “you have to find something they are really interested in.” (I, 50-51) She also indirectly referred to social learning theory when she commented, “We didn’t talk about it together, but I figured if they all talked to somebody, maybe that would help.” (I, 13-14) Barb indirectly referred to behaviorism by stating, “I gave them a point, their little rewards, because they did well today listening.” (I, 51-52)

Unfortunately, as shown in Table 11, Barb’s understandings of how learning theory influences her practice seem to have weakened from science methods class to student teaching. Barb articulated some strong links at the end of science methods class, but failed to make those understandings explicit while student teaching. During the classroom observation, it was evident that her lack of understanding of developmental learning theory inhibited her ability to select appropriate content and activities for her students. However, during the lesson it was evident that constructivism and social learning theories influenced her selection content, materials and activities.

Table 11. Barb’s understandings of learning theory and its connections to content, materials and activities.

	RBF Paper	Oral Defense	Class Observation	Interview
Behaviorism	Absent	Absent	Low	Low
Constructivism	High	Low	Moderate	Absent
Social	High	Absent	Moderate	Low
Developmental	Low	Low	Moderate	Absent

Learning Theory and its connection to Teacher Behaviors and Strategies. Barb used all four learning theories addressed in class to influence her teaching behaviors and strategies in the RBF paper. She minimally used behaviorism; therefore this link is coded as low. She wrote, “It is also helpful, especially in younger grades, if positive behavior is reinforced.” (P, 25) She wrote,” This does not have to come in the form of a tangible object but instead a

simple “thank you.”...This reinforces the positive behavior without students thinking they should receive a tangible reward for being good.” (P, 25)

Barb wrote an accurate and high understanding of how to use constructivism to inform her teaching behavior/strategies. She stated, “In order to foster higher-order thinking in students, teachers must ask deliberate questions and use deliberate actions. When asking questions it is important to ask opinion, perception, application, or experience questions rather than fact or accepted standard questions. These types of questions get to the core of the students’ knowledge and reveal to the teacher if there are any misconceptions related to the concept. When an answer is given, the teacher should ask for elaboration or clarification from the student when necessary. This puts the thinking back on the students and allows them to explain or justify their solutions or opinions.” (P, 11) She concentrated a great deal on constructivism in her paper.

Barb also articulated a moderate link to developmental learning theory. She wrote, “The teacher must evaluate his/her students and determine their strengths and weaknesses before placing them in groups. It is usually most beneficial when a variety of developmental levels and abilities are represented in each group.” (P, 8)

Barb also used social learning at a moderate level of understanding to inform her behaviors and strategies. When describing the goal of cooperative groups, she wrote, “[Social learning] theory suggests that humans learn from others and the environment surrounding them. Students learn by watching others, working together, sharing ideas, and talking amongst themselves....This theory also describes the teacher’s role as being a model for the learning environment. Some important skills students need to see modeled are good listening skills, openness to all ideas, ability to give and take feedback, ability to disagree without arguing, and being positive.” (P, 10) Generally, throughout the paper, Barb described social learning theory without specifically linking it to her teaching behaviors and strategies. When she did link the two, it was usually vague; therefore coded as moderate.

During the oral defense, the understanding Barb had of how learning theory influences her teaching behaviors was low at best. When asked what the value was of having multiple teaching strategies, Barb responded, “Kids don’t learn the same way.” (OD, 176) This demonstrates that she has some sort of link from her behaviors and/or strategies to

learning theory, but that link is rather weak. She did not articulate any other connections between her role and learning theory throughout the oral defense.

The behaviors Barb used during her student teaching lesson moderately reflect developmental, social and constructivist learning theories. She articulated that she was in a state of confusion because students did not understand the egg lesson. She couldn't simply tell students that their ideas were not what she was looking for, so she used good questioning, wait time and non-verbals to get them to understand the ideas of the lesson. Barb's behaviors also moderately reflected the behavioral learning theory. She stood at the front of the class for most of the lesson, used her non-verbals to get kids back on task, and used specific comments to direct students to pay attention. By repeating student comments and praising students, she sent the message that the students need to listen to her more carefully than they do other students. Even though Barb demonstrated several effective teaching behaviors and strategies throughout her lesson, afterwards she failed to explicitly state how learning theory influences her teaching behaviors. This is unfortunate, especially considering the high connections Barb made to constructivism throughout her RBF paper.

Table 12. Barb's understandings of learning theories and their connections to her teacher behaviors and strategies.

	RBF Paper	Oral Defense	Class Observation	Interview
Behaviorism	Low	Absent	Moderate	Absent
Constructivism	High	Low	Moderate	Absent
Social	Moderate	Absent	Moderate	Absent
Developmental	Moderate	Absent	Moderate	Absent

Barb's connections between teaching behaviors and learning theory went from moderate/high to low, then to absent, as shown in Table 12. Her connections between content, materials and activities also dropped from high/low to low for all learning theories. This drop in connections between classroom decisions and learning theory demonstrates that Barb might not use learning theory to make decisions as often as needed. Her lesson the day before the observation was developmentally inappropriate. Barb articulated to the author that she did not understand why her students were not learning what she had planned for them to

learn, so she sought guidance from her science methods instructor. This shows that she still needs to develop a working connection between developmental learning theory and her decision-making in the classroom.

Self-Evaluation. In her RBF paper, Barb described a moderate understanding of how to judge herself and her science program. She wrote, “I will assess my teaching by continuing to audiotape and videotape my teaching at least once a month.” (P, 28) She also described what she would look for on the tapes and a few techniques she could use to improve her teaching behaviors.

Unfortunately, her understandings slipped as she went from the RBF paper to the oral defense. In the oral defense, Barb focused on student achievement as a means to determine her success as a teacher. After explicit probing, she was able to generate some better understandings; therefore this piece is coded as low.

Barb’s understandings continued to slip. By the time she was interviewed during her student teaching experience, she did not mention self-assessment at all. In fact, she articulated comments that lead one to believe she was overly concerned with grades, rather than deep understanding of teaching and learning. When asked about the meaningfulness of the RBF and oral defense, Barb stated, “It was meaningful. I wouldn’t say it wasn’t. But I felt terrible after I got done because I thought I had just bombed it. Then we had to grade ourselves, ...and I think a lot of people who do what we do won’t brag about themselves. They won’t say, well, I think I deserve this. So, I put myself at a B+....I [didn’t] want to brag...I think I could have defended an A-. I got a grade in that class that I’m not comfortable with now.” (I, 88-95) Barb demonstrated and articulated understandings that show she has the potential to be an effective educator but her comment about the grade in the course leads one to wonder if she has the self-assessment capability to improve her own teaching.

Overall, Barb’s level of evaluation of herself and her teaching went from moderate, to low, to absent, as shown in Table 13. As a student teacher, Barb had no explicit sense of how to improve her practice, nor did she have an explicit sense of how to determine if she is successful in the classroom.

Table 13. Barb's understandings of how she will determine if she is a successful teacher.

RBF Paper	Oral Defense	Class Observation	Interview
Moderate	Low	Not Available	Absent

Summary of Barb's Understandings. Barb's strengths are her moderate level of tacit understandings as observed during student teaching. Overall, she demonstrated some effective teaching behaviors and strategies and planned a hands-on lesson that met some of the goals she had listed in her RBF paper. Her lesson demonstrated several of the concepts the science methods course intended for students to learn. Barb also seems to have a conscious grasp of her teaching behaviors and strategies along with the content, materials and activities that affect student actions.

Barb's weakness is articulating what she understands about her goals and learning theory. During the methods course she was able to articulate some high level connections between some components on the schematic; months later while student teaching, several of her explicit understandings had weakened. Specifically, her understandings of goals, learning theory and self-evaluation dropped off considerably.

Student C: Cassie

During student teaching, Cassie was observed teaching a lesson that was part of a unit on weather in a fifth grade classroom. Students were coming back into the classroom from a physical education (P.E.) lesson. This transition was chaotic. Students were not attentive to Cassie's directions and were difficult to get on task. Several students were late in returning from P.E. The first task was to correct the practice topic questions for the chapter in the science textbook. Students exchanged papers and checked each other's answers while Cassie read the correct answers. Eight students in the class did not have their homework finished so they sat out in the hall during this time. Those students who did have their homework done received one extra credit point.

During the next phase of the lesson, students took out their study guide worksheet for the chapter. The students were to have filled in the answers on the study guide, but it was evident that a majority of the students did not have this assignment done. Cassie asked questions from the study guide, calling on individual students to answer. If students did not have an answer or if their answer was wrong, they were to fill in the correct answers on their study guide. The following are examples of questions that were on the study guide:

1. Be able to define the following: storm surge, cold front, warm front, climate, thunderstorm, tornado, hurricane, radiative balance, and stationary front.
2. Identify instruments scientists use to study the weather.
3. Know how satellites help predict weather.
4. Know synoptic weather maps and how they are useful.
5. Explain safety precautions taken during a tornado.
6. Be able to predict weather given past weather records.

During the lesson, students were observed returning late from P.E., being off task, correcting papers, reading, filling out worksheets, answering the teacher's questions, and not completing assigned tasks. Enthusiasm for the science lesson was not evident. Much factual information was being memorized and no emphasis on the "big idea" was evident. These student actions demonstrate that, based on Cassie's RBF paper, none of her goals were being promoted. Surprisingly, even the goal of content was not promoted because it was not mentioned as one of Cassie's goals in her RBF paper.

Goals. In her RBF paper, Cassie wrote several connections between her goals, thus demonstrating a high understanding of this piece of the schematic. She wrote, "In cooperative settings, the students will think critically and be good problem solvers about their subject area or topics." (P, 7) She also wrote, "To obtain problem-solving skills the students must use many goals. They must think critically, work cooperatively, set goals for the situation, and have effective communication." (P, 11) Another connection she wrote was, "Learning to be a good citizen applies to all of the other goals." (P, 19) She ended her paper by writing, "Science is a web of intricately woven threads of goals and expectations." (P, 20)

Even though she wrote a high articulation of her goals, she only articulated a moderate understanding of her goals during the oral defense. When asked to discuss her goal of critical thinking, Cassie made the statement that critical thinking also includes such goals as problem solving and motivation. This was the only comment that explicitly connected different goals together.

Unfortunately, while student teaching Cassie did not promote the goals she articulated at the end of science methods class. Since the promotion of Cassie's goals was not observed, this element is coded as absent, as shown in Table 14.

Table 14. Cassie's understanding of her student goals and their interconnections.

RBF Paper	Oral Defense	Class Observation	Interview
High	Moderate	Absent	Low

During the student teaching interview, Cassie articulated many lofty goals for her students. In fact, when asked how the RBF influenced her teaching, she responded with, "It definitely made me look into goals, like what my goals are and how to achieve [them] and what are all these different ways I can get to my goals and think about them really in detail." (I, 53-54) When asked specifically what her goals for the lesson were, she replied, "to make sure that they are studying for their test." (I, 6) When asked if she has used some of the ideas from her RBF paper in the classroom, she immediately stated, "I would say like the cooperative learning goal that I had down...I use a lot just to kind of get the students working together and why they should be working together and just kind of how it all fits together." (I, 59-61) She went on to say, "My goals were pretty broad, so they could work for any subject." (I, 62-63) She stated, "I use them [the goals] in most of the subjects...Be a good citizen...We're always trying to make sure everyone's getting along and getting their things done...Another goal, is like, being responsible. Have them be responsible for their work and for what they're doing in class." (I, 65-69) Later in the interview, she said, "another goal I was just thinking of was like, hands-on, you know, it's hard to do that." (I, 89-90) Cassie articulated many goals for her students, but did not mention how the goals are interconnected and related, so this piece was coded as low.

Content, Materials and Activities. In her RBF paper, Cassie moderately linked her materials and activities to her student goals. On page 8 she wrote, “Visuals and tangibles aid in the active learning process. The students can use aids to actively learn and critically think.” She also wrote, “Extrinsically motivating objects such as: candy bars, pens, and stickers are all good ways to motivate students if the teacher doesn’t over use them.” (P, 14) She mentioned several activities and how they connect to her goals. She wrote, “Students can use written communication, journals, writing assignments, and word walls to express themselves non-verbally.” (P, 12) Cassie did not mention content and how it helped her students reach their goals, so this link was coded as absent.

During her oral defense, Cassie articulated a moderate understanding of her content, materials, and activities and their connections to student goals and actions. When asked a specific, concrete question like, “What would you do to meet your goal of critical thinking?” Cassie was able to make good connections. But when asked, “How will you decide what (content to teach, activities to use with, or materials to use with) your students?” Cassie did not articulate that she had her goals in mind when making such decisions.

Despite her explicit connections between her goals and content, materials and activities at the end of science methods class, Cassie did not promote any of her goals in the lesson observed during her student teaching experience.

Even though Cassie did not select content, materials or activities that promoted her goals during the observed lesson, she articulated a high connection between her goals and the content, materials and activities selected to promote specific student actions. In order to meet the goal of content, “we basically do a lot of reading through the materials and answering some questions at the end [of the chapter].” (I, 17) To meet the cooperative learning goal, she said they “[get] into groups to discuss some things and to study topic practices.” (I, 18-19) She mentioned that they had previously, “watch[ed] some videos on weather.” (I, 23) But most of what they do in science is “out of the textbook.” (I, 24) She articulated that she wants everyone to “[get] along and [get] their things done” to demonstrate good citizenship (I, 67-68). She also articulated a struggle with her attainment of a goal. She said, “Hands-on...oh, that’s easy enough...but I’m like struggling now...Its just because we have to get

through these chapters and get this material [done] and when do you throw in hands-on and exciting stuff?” (I, 90-93)

Cassie’s strength is her understanding and use of her goals. Even though, the level of interconnectedness dwindled from methods class to student teaching, she was able to articulate several goals and what she would do for students to meet them. Another strength of Cassie is her ability to articulate the content, materials and activities she will use to attain her goals. As shown in Table 15, this link went from moderate to high, so it seems as though Cassie has deepened her understanding of this connection. Even though Cassie was able to articulate her goals and the content, materials and activities to achieve those goals, her tacit understanding doesn’t match what she says. There is a huge discrepancy between what she says and what she does because her observed lesson did not promote any of her goals.

Table 15. Cassie’s understanding of content, materials and activities and their connections to student actions and student goals.

RBF Paper	Oral Defense	Class Observation	Interview
Content—Absent Materials—Moderate Activities—Moderate	Moderate for all 3	Absent for all 3	High for all 3

Teacher Behaviors and Strategies. Cassie’s writing reflected a low understanding of teaching behaviors. She made brief comments about her teaching behaviors, such as “wait time is a very important role for the teacher.” (P, 6) Infrequently she made vague connections to her goals, like “Questioning, modeling, and wait time is very important in developing problem solving skills.” (P, 10) Throughout the paper, she made several vague connections from her teaching strategies to student goals, such as “The teacher should be a good model for goal setting.” (P, 3) She also wrote, “The teacher’s job in critical thinking is to observe the students.” (P, 8) To improve student intrinsic motivation, teachers should be “involving students in the learning process...promoting mastery learning, providing stimulating challenges, and evaluating the task rather than the student.” (P, 15) Overall her connections from teaching strategies to student goals showed a moderate understanding.

Cassie articulated her teaching behaviors and strategies at a low level during her oral defense. She mentioned wait time and questioning without any prompting, but failed to mention nonverbals or responding patterns when asked how she would facilitate the goal of critical thinking. She did not mention her teaching behaviors or strategies at any other time during the oral defense. When asked what the value of multiple strategies are in a classroom, Cassie replied that everyone is different, so multiple strategies will reach more students. She also mentioned if one failed, then the teacher would have others to try. These statements also support the conclusion that Cassie had a low understanding of this piece of the schematic and how it connects to the other components.

Cassie demonstrated very few effective teacher behaviors while student teaching. She primarily asked yes/no and short answer questions, showed poor wait time I and II, was impatient with the students and exhibited very harsh non-verbals and tone of voice. She spent her time monitoring behavior and giving directions, rather than eliciting students' thoughts. Her teacher behaviors were coded as absent because she used them primarily for behavior management and the elicitation of correct answers, rather than promoting learning and her other goals. Consistent with her lack of tacit understandings of the teacher's role, Cassie failed to articulate her role in the classroom during her student teaching interview.

A very weak area for Cassie is her teaching behaviors. During the science methods course, she articulated them at a low level; however her explicit understandings dropped off entirely while student teaching, as shown in Table 16. It could also be argued that she showed no tacit understandings of the component either, because her teaching behaviors were extremely teacher-centered and didn't exhibit any of the components discussed during science methods class.

Table 16. Cassie's understandings of effective teacher behaviors and strategies.

RBF Paper	Oral Defense	Class Observation	Interview
Behaviors—Low Strategies—Moderate	Low for both	Absent for both	Absent for both

Learning Theory and its connection to Content, Materials and Activities. In her RBF paper, Cassie used all four learning theories at a low level to select her content, materials and activities. After Cassie wrote about the activities of written communication, journals, writing assignments, and word walls she made the statement, “learning theory states that the class should be communicating as much as possible.” (P, 12) After discussing materials that students might find extrinsically motivating, she wrote, “The behavioral theory suggests that sometimes extrinsic motivation is good for very unmotivated students.” (P, 14) On page 17, she wrote, “the teacher should test the student’s prior knowledge by using pre-tests, observations...and journals.” Her references to constructivism centered upon finding students’ prior knowledge. She made only one comment connected to developmental learning theory. On page 18, she wrote, “character education must be appropriate to the developmental level of the students.” Her connections to learning theory seemed vague and seldom occurred.

During her oral defense, when asked how she would decide what content to teach her students, Cassie responded with a very weak understanding and connection to constructivist learning theory. She mentioned the need for the teacher to know the students’ prior knowledge. She also made a low connection to developmental learning theory. She mentioned the need for content to be based on the grade level or correct level for the class. She then said this would tie in with the developmental theory. She did not discuss the concrete or abstract nature of the content, only that it needs to be at the right level. Cassie did not mention behavioral or social learning theory and how it influenced her selection of content, materials and activities.

Unfortunately, the content, materials, and activities observed during her student teaching experience were primarily used for on-task behavior and secondarily for learning goals, which focused on the correct answers. After the lesson, Cassie did not mention anything that could be interpreted as a link to a learning theory.

As shown in Table 17, Cassie’s understandings of how learning theory influences her selection of content, materials and activities weakened over time. Even though she mentioned constructivism during science methods class, she did not use that theory to make decisions in her classroom while student teaching.

Table 17. Cassie's understanding of learning theories and their connections to content, materials and activities.

	RBF Paper	Oral Defense	Class Observation	Interview
Behaviorism	Low	Absent	High	Absent
Constructivism	Low	Low	Absent	Absent
Social	Low	Absent	Absent	Absent
Developmental	Low	Low	Absent	Absent

Learning Theory and its connection to Teacher Behaviors and Strategies. In her RBF paper, Cassie did not use behavioral or developmental learning theories to influence her teaching behaviors and strategies. Her connections to social learning theory showed a low understanding. Cassie wrote, "The teacher should be a good model for goal setting. This would go along with the social learning theory." (P, 3) She demonstrated a moderate understanding of constructivism throughout the paper. On page 6 she wrote, "Knowing the students' prior knowledge, experiences, and interests can help the teacher group the students correctly." She also wrote that in order to "figure out what they already know" the teacher should use "good questioning techniques." (P, 8) Another reason Cassie asks questions is to "get the students critically thinking about the problem." (P, 10) Overall, these accurate connections to constructivism seldom appear in her paper.

During her oral defense, Cassie connected her questioning behavior to constructivist learning theory at a low level of understanding. She said that questioning would be good because it puts the learning back on the students and helps them think in new ways. She did not use the other three learning theories to influence her behaviors and strategies.

Even though Cassie focused on constructivism in her paper, based on observation, the only learning theory used to influence her teaching behaviors was behaviorism. The teaching behaviors were used to elicit the correct answers and on task behavior. This is highly unfortunate because Cassie is not consistent between what she says she wants to do and what she actually does in the classroom. Later in the interview, Cassie did not mention any connections between her behavior and learning theory. This demonstrates that her explicit understandings of these connections weakened since science methods class.

A weakness Cassie demonstrated was her lack of understanding about learning theory and how to use it to influence decisions in the classroom. As shown in Table 18, both connections from learning theory started as low to moderate links and then shifted to low, and eventually were absent in the student teaching interview. Even though she spent most of her time in her paper and oral defense discussing constructivism, and social and developmental learning theories, the only learning theory evident during her observation was behaviorism. Again, what Cassie says and what she does are two different things.

Table 18. Cassie's understanding of learning theories and their connections to effective teacher behaviors and strategies.

	RBF Paper	Oral Defense	Class Observation	Interview
Behaviorism	Absent	Absent	High	Absent
Constructivism	Moderate	Low	Absent	Absent
Social	Low	Absent	Absent	Absent
Developmental	Absent	Absent	Absent	Absent

Self-Evaluation. At the end of the paper, Cassie showed a high understanding of how she will evaluate herself and her program. On page 19 she wrote, "When I am assessing myself I will look at my questioning techniques, wait time, non-verbals, verbals, and placement in the room. I can assess this by videotaping, tape recording, and other colleagues' input, and SATIC coding my questions."

During her oral defense, Cassie said she would look at her students' achievement in order to determine if she is a successful teacher. Even after prompting pointed out potential discrepancies between students based on economic, social, and geographic status, she still thought student achievement would be a sufficient indicator of effective teaching. This demonstrates a low understanding of self-assessment.

Cassie demonstrated no explicit knowledge of how to evaluate herself while student teaching. Overall, her explicit understanding of this component changed from high, to low, to absent, as shown in Table 19.

Table 19. Cassie's understanding of how she will determine if she is a successful teacher.

RBF Paper	Oral Defense	Class Observation	Interview
High	Low	Not Available	Absent

Summary of Cassie's Understandings. Overall, the lesson observed during Cassie's student teaching experience was consistent with research done on ineffective science instruction (Goodlad, 1983; Yager & Penick, 1983). Cassie had several goals for her students, but failed to teach in a manner that would promote them. Her focus was on behavior and classroom management rather than learning. Unfortunately, the learning that did occur in her classroom consisted of memorization of random facts, rather than a synthesis of a big idea or concept. Very few of the ideas the science methods class intended for students to learn remained with Cassie as she transitioned to student teaching.

Student D: Denise

During student teaching, Denise was observed teaching a lesson that was part of a unit on rocks in a 3rd grade classroom. Prior to the lesson, students had made observations of mock rocks, recorded these observations on a worksheet and put some crushed part of the rock in water and left it so the small pieces would settle out. The observed lesson began with students sitting in rows. Denise asked several questions in order to review with the students what had been done previously. Elicited student responses were printed on the board. Denise made a point to model how the information should be written on student papers. She also was thorough and explicit on how students should label numbers on their papers. Denise led the class in a discussion on the similarities and differences between mock rocks and real rocks. Again, student ideas were printed on the board. Denise did reject some ideas though, because she did not write all student ideas on the board. She added a few ideas if students did not come to the idea on their own.

For the second part of the lesson, students physically moved their desks into groups of four. One person from each group was called upon to retrieve the group vial of rocky sediment. The group was to make new observations on the water and rock sediment. The

students discussed their findings and wrote down what they observed. When it was evident students were getting off task, Denise brought the group together into a class discussion on their observations. At the very end of the lesson, each group poured part of the water from their vials into a petri dish. The students put all their materials back on the science table and left their labeled petri dishes open to the air so the water would evaporate.

During this lesson, students listened, shared ideas, wrote observations, worked with others, showed respect for others, and followed class rules. Students cleaned up after themselves and seemed interested in the lesson. These student actions demonstrate that the goals promoted by the lesson, as stated in Denise's RBF paper, were 1) Students will use prior knowledge, 2) Students will demonstrate an understanding of the content, 3) Students will work cooperatively, 4) Students will show enthusiasm and motivation, and 5) Students will develop personally and socially.

Goals. In her RBF paper, Denise wrote, "Teachers need to be aware of that (sic) everything they do in the classroom is intertwined." (P, 3) She went on to make a general statement about her goals; "Although all of the goals I have set for my classroom intermix, I have separated them to explain each individually." (P, 3) These statements are vague and do not mention specifically how her goals connect, therefore, Denise has a low understanding of this element. Although Denise made a general statement about the connectedness between student goals in her paper, she failed to articulate these connections during her oral defense at the end of the semester.

The lesson Denise taught promoted five goals; therefore, this element is coded as moderate, shown in Table 20. It is encouraging to see her teaching for more than just the goal of content, however, during her student teaching interview, she only articulated one goal for her students. She said she wanted her students to "become better observers of the world around them [and] discover that rocks are made up of many materials." (I, 7-8) Denise later commented more on her understandings of goals as related to the RBF process. "I didn't really get the point of the RBF and the oral defense. I understand the part about making classroom goals, but what does that have to do with science?" (I, 58-59) These comments

clearly articulate that Denise does not explicitly understand the meaning or use of broad goals in the teaching of elementary science.

Table 20. Denise's understanding of goals and their interconnections.

RBF Paper	Oral Defense	Class Observation	Interview
Low	Absent	Moderate	Absent

Content, Materials and Activities. In her RBF paper, Denise wrote about several activities, such as “KWL-Charts, interviews, class discussions, journal prompts,” pen-pals, role-playing, working in teams, and service programs (P, 4). For every goal, Denise mentions activities and generally makes rather vague connections from activities to her goals. One example is, “Role-playing and working in teams will help foster growth in the social skills of young people.” (P, 13) These vague connections are interpreted as a moderate link between activities and student goals.

She also wrote about materials that might be used to get to her goals, but they were only mentioned briefly. She wrote, “Technology, such as the use of motion pictures, television, and videotapes can increase students’ motivation.” (P, 12) She also wrote, “newspapers in the classroom can supply problem-solving opportunities with connections to science and other interdisciplinary areas.” (P, 10) Even though Denise vaguely linked materials to goals, she did so very infrequently, so this link is coded as low.

Content was mentioned once in her RBF paper. She wrote, “They can look at who contributed to different ideas, such as how the Chinese contributed to calendars, and how the Mayan culture contributed to the number system.” (P, 9) This is coded as low because it is not explicitly linked to her goals.

During her oral defense, Denise stated a low understanding of how her content, materials and activities would promote her student goals. Initially, she chose to articulate how she would facilitate the goal of problem solving in her classroom. She only mentioned four strategies to obtain that goal. When probed, she still did not communicate a deep understanding of this link.

Even though Denise had troubles at the end of science methods class articulating how her content, materials or activities would promote her student goals, she was able to select content, materials and activities for her student teaching lesson that promoted several of her RBF student goals. Afterwards, when asked what evidence she had that students are meeting her goal, Denise replied, “We have class discussions. They fill out journals about what they discover.” (I, 11) Denise articulated a moderate understanding that content, materials and activities affect the student actions and attainment of a goal.

Denise’s strength is her understanding of the content, materials and activities and how they influence the student actions she desires. As shown in Table 21, her understanding of this component stayed the same or increased slightly from science methods to student teaching. Denise also demonstrated moderate tacit understandings of the key components of the science methods course while student teaching. Even though she can articulate some connections, she definitely does some of these things better than she can express them.

Table 21. Denise’s understandings of content, materials, and activities and their connections to student actions and student goals.

RBF Paper	Oral Defense	Class Observation	Interview
Content—Low Materials—Low Activities—Moderate	Low for all 3	Moderate for all 3	Moderate for all 3

Teacher Behaviors and Strategies. In her paper, Denise wrote a low understanding of both teaching behaviors and teaching strategies. She mentioned good questioning techniques a few times in the paper. She described wait time once when she wrote, “Using wait time in the classroom will improve higher order thinking skills in students....Wait time I allows students time to think about their responses before shouting out an answer. It also allows students who think slower time to think about their answer. Wait time II allows the student time to think about their response and add to their responses if they need to.” (P, 11) Both of these teaching behaviors were moderate in quality, but very low in frequency throughout the RBF paper. Some teaching strategies Denise wrote about were: modeling, reflective thought,

interviewing students, fostering a cooperative environment, observing students, and having high expectations. Unfortunately, these strategies were not frequent in the paper and were generally written as stand alone statements with no explicit link to student goals.

During her oral defense, Denise's understanding of teaching behaviors and strategies was low, at best. She did mention questioning without an explicit prompt. But two times she referred to her role in the classroom as "keeping them on task." (OD, 78) When specifically asked what her role in the classroom was, she gave a response that was inarticulate and vague.

Denise's tacit knowledge of her teaching behaviors and strategies was consistent with her explicit knowledge of this element during science methods class. Denise demonstrated a low understanding of teaching behaviors. Her nonverbals could be classified as passive. She did not demonstrate enthusiasm. Toward the end of the lesson, many students were getting restless and off-task. Denise used a clapping rhythm to get their attention. Near the end of the lesson, the clapping technique was not working very well. More assertive nonverbals may have kept the students on-task. She did, however, use nonverbals to model techniques and data collection. The following are some questions Denise asked during the whole group discussions:

"What did we do with the rocks?"

"What were some observations you made?"

"Does anybody remember how we measure the diameter?"

"What did we use to measure it?"

"What was the circumference?"

"How did we measure that?"

"What is a mock rock made up of?"

"Are there any ingredients we can add to our list?"

"What do you think we can do to the water to break it down even more?"

This question elicited no student ideas. Denise had them discuss the question with their group members.

"What is evaporation?"

A couple of these questions elicited student thinking, but many of them required students to simply read the answers off their worksheet. After asking these questions, Denise usually demonstrated good wait time one. While students were working in their small groups, Denise did not ask probing questions. She walked around the room, watched groups and only engaged in conversation with students if they were getting off-task. Denise's responding pattern was teacher-centered. Her teaching behaviors would promote some of the goals she had for her students, but much improvement in this area is needed.

During the interview, Denise felt her role in the classroom was that of a "facilitator. I make sure that the students are heading down the right path of discovery and put them back on track if they get off task. I ask the students questions to guide their learning." (I, 14-16) She sees herself as a facilitator but she did not articulate this vague conception clearly. She understands that her behavior affects classroom management, but, unfortunately, does not fully articulate the connection between her role and classroom learning, so this was coded as low. Teaching behaviors and strategies are weak for Denise. As shown in Table 22, her understandings were low across all data sources. She could not articulate them very well, nor could she demonstrate them well, either.

Table 22. Denise's understandings of effective teacher behaviors and strategies.

RBF Paper	Oral Defense	Class Observation	Interview
Low	Low	Low	Low

Learning Theory and its connections to content, materials, and activities. Denise used constructivism and developmental learning theories to select her content, materials or activities in her RBF paper. She wrote, "Finding a student's prior knowledge can be done using KWL Charts." (P, 5) She explains what a KWL chart is. She states, "Teachers use the 'What we Know' column of the KWL Chart as a place to begin teaching the students. This column also informs teachers about misconceptions that students may have." (P, 5) Her understanding of how constructivism impacts her content, materials and activities is definitional and vague; therefore coded as moderate.

Denise also wrote, “Teachers need to understand learning theories and how students learn, because the material they are presenting needs to be age appropriate....When teaching by the developmental learning theory, teachers divide the students up based on what level they are at. Students have individual projects that they work on, depending on what level they are in. From a constructivist’s point of view, the teacher modifies lessons to build on the students’ prior knowledge. Students piece together the new information with their prior knowledge.” (P, 6-7) Overall, her understanding of developmental learning theory is inaccurate because teachers do not teach by a theory. Instead, learning theories should influence the decisions made by a teacher in the classroom; therefore this link is coded as low.

During her oral defense, she also articulated a low understanding of learning theory and how it affects the selection of content, materials and activities. She mentioned a low understanding of developmental, social, and constructivist learning theories, but only when specifically prompted to connect the selection of content, materials and activities to how children learn.

The content, materials and activities used during the observed lesson were moderately consistent with developmental, social and constructivist learning theories. All parts of the lesson were developmentally appropriate. Students shared their ideas with the class and also with their small groups. The lesson was structured so that students were not being told information, but were to use the activities, class discussions and their own thinking to learn the science ideas. The content, materials and activities minimally reflected behaviorism. Students filled out a worksheet and classroom management techniques were utilized to control student behavior throughout the lesson.

Table 23. Denise’s understandings of learning theories and their connections to content, materials and activities.

	RBF Paper	Oral Defense	Class Observation	Interview
Behaviorism	Absent	Absent	Low	Absent
Constructivism	Moderate	Low	Moderate	Absent
Social	Absent	Low	Moderate	Absent
Developmental	Low	Low	Moderate	Absent

Even though Denise's lesson was influenced by several learning theories, she did not articulate any understanding of how learning theories impact the content, materials and activities she selected for the lesson. As shown in Table 23, her understandings of this link on the RBF schematic weakened over time.

Learning Theory and its connections to teacher behaviors and strategies. Denise used behaviorism, constructivism and social learning theories to influence her selection of teaching behaviors and/or strategies in her RBF paper. She wrote, "Teachers following the behavior learning theory will be showing their students how to do things using guided practice. Students copy the teacher's model. The social learning theory also involves teachers modeling." (P, 7) She wrote, in a few instances, how teaching behaviors, such as questioning and wait time, could promote student thinking. For instance on page 4, she writes, "Sometimes, students are misinformed or draw false conclusions from previous experiences. In this case, teachers need to be prepared to steer them in the correct path. This can be done through effective questioning techniques." Her understanding of constructivism is coded as moderate, while behaviorism and social learning theory are incomplete and coded as low.

Even though she made connections to learning theory in her paper, Denise did not use a specific learning theory to influence her teaching behaviors and strategies while in the oral defense. When asked what the value is of having multiple strategies, she replied that a variety of strategies would make school less boring. This statement is disturbing and shows that her understanding of this part of teaching is low, at best.

The behaviors Denise demonstrated while student teaching were moderately consistent with developmental, social and constructivist learning theories. She let students discuss things in their groups, she modeled techniques for the students, and she tried to use questioning to get students to understand an idea. Denise also moderately demonstrated the influence of behaviorism on her teaching behaviors. She was looking for the correct answer on the worksheets, she seemed to be more concerned about on-task behavior than what the students were thinking while they were working in their small groups, and she used her non-verbals and wait time to help her manage classroom behavior.

After the lesson, Denise indirectly articulated an understanding of how constructivist learning theory impacts her behaviors. She stated, “I have a hard time letting the students take over and become independent learners as opposed to me feeding it into them. They learn better from themselves though! Learning is more meaningful that way.” (I, 33-36) This statement is vague and confusing, which conveys a low understanding of this link.

Overall, her connections from learning theory to her teaching behaviors and strategies are low and weak, as shown in Table 24. It is encouraging that she demonstrates these behaviors better than she can articulate them.

Table 24. Denise’s understandings of learning theories and their connections to effective teacher behaviors and strategies.

	RBF Paper	Oral Defense	Class Observation	Interview
Behaviorism	Low	Absent	Moderate	Absent
Constructivism	Moderate	Low	Moderate	Low
Social	Low	Absent	Moderate	Absent
Developmental	Absent	Absent	Moderate	Absent

Self-Evaluation. In her RBF paper, Denise had a high understanding of how she would determine if she was an effective teacher. She wrote that she would “audio and videotape” herself, use the “SATIC coding sheet” to assess her questions, and ask “colleagues” to assess her teaching (P, 14). During her oral defense, Denise articulated a low understanding of self-assessment. She focused on student achievement in her response. While student teaching, Denise failed to mention anything about self-assessment. As shown in Table 25, these understandings weakened over time, which is unfortunate because self-assessment, along with knowledgeable colleague and student assessments, are useful in improving a person’s teaching practices.

Table 25. Denise’s understandings of how she will determine if she is a successful teacher.

RBF Paper	Oral Defense	Class Observation	Interview
High	Low	Not Available	Absent

Summary of Denise's understandings. Denise's strengths are her tacit understandings of goals, and how content, materials and activities are used to reach those goals, as observed during student teaching. She planned a hands-on lesson that moderately reflected constructivist, social and developmental learning theories.

Three links on the schematic weakened from science methods to student teaching: goals, learning theory connected to content, materials, and activities, and self-assessment. Denise did not understand the purpose of having goals; this explains why she wouldn't articulate them or think about them while she teaches science.

Sample From Class B

Student E: Evelyn

The lesson observed during Evelyn's student teaching experience was part of a phonics unit on letters in a kindergarten classroom. Unfortunately, Evelyn was not explicitly teaching science during her student teaching placement. As stated earlier in the methodology section, this may limit the richness of these data, but the elements of teaching Evelyn used to teach phonics should be similar to the elements of teaching she would use to teach science. The lesson began with students arranged in a large circle, sitting on the floor. Evelyn asked, "What can you think of that starts with the letter V?" Some students raised their hands to be called on, while other students just blurted their ideas out. Evelyn had to remind students to raise their hands. The students had several ideas of things that began with the letter V. After this initial discussion, she gave each student a brown grocery bag cut to look like a vest. As soon as students received their paper vest they immediately went to the magazine pile, or to their respective tables to get their scissors and glue ready. Every student went right to work and made his/her own choices about where to work, how to go about the activity, and who to talk to. Some students sat on the floor, others sat near the magazines, while the rest sat at their tables to work. All students talked while they worked; most discussions were about the activity. They would remind each other of things that they were looking for, comment on other students' vests, or comment on the colors, shapes etc... of items they were cutting out. Most students showed genuine excitement throughout the lesson. At the front of the room were copied pages with vegetables printed on them. One girl noticed these and asked if she could color, cut and paste them on her vest. This girl started a trend; once students noticed they could color and cut vegetables to add to their vest, they got excited and worked diligently to color their vegetables. Some of the students would ask questions about the color or kind of vegetable on the page. They took great pride in coloring neatly. Ultimately, they took great pride in the vests they created.

After several minutes, some students were done with their vests and center time started. Students naturally formed groups and moved into the new activity. Students worked at the computer station, built things on the floor using materials or toys, or drew on the easel.

Students who wished to continue working on their vests did so. At the end of the lesson, the students picked up the room. Some students showed much responsibility and leadership. All students had a smile on their face while they picked up their tables, the magazine pile, and any scraps of paper on the floor. After the room was cleaned, the students put their vests on and gathered together for a group photo. During the lesson, Evelyn had a video camera running to record her teaching. The student actions demonstrate that the goals promoted by the lesson, as stated in Evelyn's RBF paper, were: 1) civic/social skills, 2) self-worth, 3) effective communicators, 4) creativity, 5) conceptual understanding, and 6) cooperative learners.

Goals. Evelyn made some proper connections between the goals in her RBF paper; her understanding of this piece is moderate. She wrote, "Started early, this will also help students themselves become better communicators, develop better social skills, and have a conceptual understanding of the content. (Connections!!!)" (P, 7) She made several other connections, one of which was, "Students will be active in the classroom by doing group work, which will require participation of all students (as discussed earlier) and contributing their ideas." (P, 3) Even though Evelyn made some connections, there were others she missed. Usually she did not explain why or how the goals were connected.

During her oral defense, Evelyn also articulated a moderate understanding of student goals. She listed several goals, such as social skills, self-worth, and teamwork in order to justify her decision to use cooperative learning in her classroom. Several of her responses demonstrated a high reasoning level.

The lesson she taught while student teaching promoted several goals, therefore, her implicit understanding of goals and their interconnections is coded as high, as shown in Table 26. After the lesson, Evelyn articulated a low understanding of her student goals. When asked what her goals were she replied, "to recognize v words." (I, 5) Later on in the interview when asked how the RBF influenced her teaching, she said, "It makes you think...My goal is to get them to read or my goal is to get them to know their letters. It's also citizenship and sharing and...respecting other people." (I, 65-66) She also said that she wants students to "[make] sure they can do it themselves. Which was...self-learning." (I, 84)

Evelyn said, “I do use [my goals, but] I don’t think about my RBF when I’m using them.” (I, 78) Evelyn articulated how she uses her goals daily and describes an example. A student might come up to her and say, “So and so stole my picture.” (I, 83) Evelyn responds to the student with, “You know, that’s theirs, not yours.” (I, 83) These statements imply that Evelyn uses her goals in all contexts of the classroom, not just as one aspect of a lesson, but she does not explicitly articulate the connections between her different goals and how they interact.

Table 26. Evelyn’s understandings of student goals and their interactions.

RBF Paper	Oral Defense	Class Observation	Interview
Moderate	Moderate	High	Low

Content, Materials and Activities. In her paper, Evelyn wrote a high understanding of the connections between activities and student goals. She extensively mentioned activities throughout the paper and linked them to her goals. For example, she wrote, “My students will obtain the ability to exhibit civic/social skills through working in groups, taking turns, and being reminded to use politeness when corresponding with classmates and teachers. When students work on social skills by role playing, working as a team, and respecting others, their social skills and behaviors improve.” (P, 2) On page three she stated, “My students will develop self worth through trying out their own ideas, being responsible for those ideas, and either modifying them or explaining them to others. They can do this by writing their ideas on the board so that they feel that those ideas are important to the class. Testing their ideas is a way they can be responsible for them. They will decide what to do, what materials to use, and how to carry out the test.”

Even though her connections to activities were high, her connections to content, and materials were low. She listed materials as being useful for her goals, but only mentioned them twice in her paper. She thought books would be important. She also wrote, “Manipulatives provide hands-on learning for creative thinking.” (P, 16) Evelyn also demonstrated a low understanding of the connections between content and her student goals.

She referred to content once in her paper by writing, “I would also teach basic character skills.” (P, 2)

During her oral defense, Evelyn articulated a moderate understanding of how her content, materials and activities are used to elicit student goals. Her response to the question, “How would you decide what content to use with your students?” was high and demonstrated links between learning theories, goals and content, materials and activities; however, her response defending her cooperative grouping strategy demonstrated low reasoning and understanding. Overall, her understanding of this link was moderate.

The lesson Evelyn planned while student teaching demonstrated a high level of implicit understanding. Her content, materials and activities were appropriately used to promote several goals simultaneously.

After the lesson, Evelyn articulated, at a high level, how her content, materials and activities promoted her student goals. The students had to “actually find stuff that starts with [the letter] v.” (I, 6) Evelyn also described how the class discussion at the beginning of the lesson tied in with what the kids were later asked to do; “that’s why we kind of did the words that started with v before [the activity] so they had some ideas of what [they] were going to look for.” (I, 21-22) Overall as shown in Table 27, Evelyn’s understandings of this element of teaching stayed about the same from science methods to student teaching.

Table 27. Evelyn’s understandings of content, materials and activities and their connections to her student actions and student goals.

RBF Paper	Oral Defense	Class Observation	Interview
Content—Low Materials—Low Activities—High	Moderate for all 3	High for all 3	High for all 3

Teacher Behaviors and Strategies. Throughout her RBF paper, Evelyn showed a moderate understanding of her teaching behaviors and how they promoted student goals. She accurately mentioned behaviors but did not include them for all her student goals. On page 3 she wrote, “My role in helping to develop self worth is to ask questions so that students

provide reasoning for their answers, and therefore are confident with their opinions.” For one goal she wrote, “Some of the things I can do to show that I am an effective communicator are: be interested avoid dead-end questions, extend conversation, share my thoughts, define and reflect on my feelings, and observe cues from the student. I need to look at them when they are talking to show interest, and ask good #11 and #12 questions. Avoid yes/no or short answer questions which require no thought. I also need to give them time to answer questions (wait time) and extend the conversation so that I can fully understand what they are trying to say. I also need to observe their body language and make sure mine is appropriate.” (P, 8)

Evelyn demonstrated a high understanding of her teaching strategies and how they connect to student goals. On page two she wrote, “My role in teaching civic/social skills is to group students frequently so that they can have experiences working together, setting up duties for the groups this way they all have a job and they all need to be focused on the lesson...Another role I have is to take students outside the classroom so that they can practice these skills in other settings. Field trips are a great way to practice using social skills.” For her goal of self-worth she wrote, “I need to be encouraging students to be actively involved in the classroom and other activities, by talking, taking notes, or being an active listener, so that they get a feeling of importance and realize they can make a difference.” (P, 3) Throughout the paper, Evelyn fully explained her strategies and their connections to her students’ actions and goals.

During her oral defense, Evelyn articulated a moderate understanding of teaching behaviors and strategies. When asked how she would facilitate her goal of self-worth, she replied with several teaching strategies and one teacher behavior, questioning. Later on in the defense, she articulated a vague notion of responding patterns when specifically asked about her role in facilitating group discussions. Her response defending her practice of responding to a student’s question with a question was high. She replied that questioning helps her students meet more of the goals she has for them.

While student teaching, Evelyn demonstrated a moderate implicit understanding of teacher behaviors and strategies. Her initial directions and questions were appropriate. Throughout the lesson, she tended to repeat student comments. Her non-verbals showed

enthusiasm for teaching. She walked around the room and interacted with students while they worked. Most of the time she did not need to initiate the interaction. Students were constantly coming up to her, telling her what they found or what they did. She would respond to these students with, “Good job.” Some students had a difficult time finding a picture of something that started with the letter V, so Evelyn would find a page with one and tell the student, “There’s one on this page.” Some other comments Evelyn made to her students were, “Can you share?” or “good idea.”

After this lesson, Evelyn described her role in the classroom as “just making sure they’re staying on task...and they’re not getting too crazy.” (I, 14-15) She went on to articulate that if the students “can’t find anything...they’ll just want to quit, so” (I, 16) she will “usually find a page that has a v word on it and ...say, ‘I found one on this page.’” (I, 19-20) Evelyn feels the hardest part of teaching is “giving directions because [she] assume[s] that [the students] know more than they do.” (I, 53-54) Evelyn also said, “Every now and then...I’ll all of a sudden think, ‘I wonder what I look like to them?’” (I, 107-109) She commented that she videotaped herself earlier in the semester and found she “looked so [irritated] the whole time.” (I, 110) She went on to say, “If I seem more excited, they get more excited about it.” (I, 111) All of the articulations Evelyn made about her teaching behaviors were not linked to her student goals or actions. Unfortunately, many of her comments reduced her teaching behaviors to simply controlling classroom management; therefore, this link was coded as low.

As shown in Table 28, her articulations on teacher behaviors dwindled over time. Her moderate to high levels of understanding fell back to a low level understanding while student teaching. However, Evelyn demonstrated a higher tacit understanding of this link than she could articulate during student teaching.

Table 28. Evelyn’s understandings of effective teacher behaviors and strategies.

RBF Paper	Oral Defense	Class Observation	Interview
Behaviors—Moderate Strategies—High	Moderate for both	Moderate for both	Low for both

Learning Theory and its connections to Content, Materials and Activities. In her RBF paper, Evelyn made connections between content, materials and activities and learning theories. Her connections to constructivism demonstrated high understandings. She wrote, I can find out prior knowledge by asking questions, having them write short letters telling what they know so far, or using KWL charts.” (P, 7) She also wrote, “New knowledge should be integrated into existing structures in order to be remembered and receive meaning... Concept mapping and making KWL charts are both great ways to find out what a student’s prior knowledge consists of and build upon that knowledge.” (P, 18) On page 19 she continued her connections to constructivism by writing, “They can also do jigsaw where groups break apart to share information and gather from other people, then return to share that new information with those in the group. Working together in this way makes it easier for the teacher to spot misconceptions also.” Evelyn’s connections to developmental learning theory were moderate. She wrote, “We need to pay attention to what concept we are teaching and if it [is] developmentally appropriate first of all.” (P, 17)

During her oral defense, Evelyn used a moderate understanding of learning theory to select her content, materials and activities. She used developmental learning theory at a high level of understanding to select her content. When specifically asked to use learning theory, she articulated that cooperative groups are used because students learn by teaching others, this implicitly describes a low understanding of social learning theory. Later in the oral defense, Evelyn was specifically directed to use constructivist learning theory and she did so at a low level of understanding.

The content, materials and activities Evelyn selected for her student teaching lesson were highly consistent with the constructivist, social and developmental learning theories. The lesson was developmentally appropriate in all aspects. The students were engaged in social activity, asked each other questions, and ultimately learned from each other. The students naturally formed groups to work on their activities. Students were not told exactly what to do. They had several decisions to make and were given the freedom to make those choices. Behaviorism was lowly reflected in the lesson. Coloring, cutting and pasting are skills that require practice to gain efficiency and are skills all young children work on to master. These skills were part of the lesson, but were not the focus of the learning.

Unfortunately, Evelyn did not articulate any connections to learning theory during her student teaching interview. As shown in Table 29, her high explicit connections to learning theory weakened over time.

Table 29. Evelyn's understandings of learning theories and their connections to content, materials and activities.

	RBF Paper	Oral Defense	Class Observation	Interview
Behaviorism	Absent	Absent	Low	Absent
Constructivism	High	Low	High	Absent
Social	Absent	Low	High	Absent
Developmental	Moderate	High	High	Absent

Learning Theory and its connection to Teacher Behaviors and Strategies. Evelyn demonstrated a moderate understanding of how constructivism influences teacher behaviors and strategies in her paper. For example, she wrote, "I can find out prior knowledge by asking questions." (P, 3) Higher order questions will also "get the students going on why they think what they do, and get them to see another side that they haven't thought about yet," (P, 11) along with letting the teacher "dig deeper into [the] student's knowledge base." (P, 18) Evelyn also mentioned social learning theory, but at a low level. She wrote, "The social learning theory says that they learn by example, and watching the teacher read and display a love of books is a great example to set." (P, 15)

During her oral defense, Evelyn used learning theory at a low level to influence her teaching behaviors and strategies. Her response to the value of multiple strategies was moderate. She stated, "I don't think everyone is the same at all." (OD, 768) She also articulated that because students are different, they learn differently. She also gave a low response to the issue of teacher questioning in her classroom. She said that responding to a student question with a question is useful because it is good for the students to struggle. She did not explicitly use learning theory in any other way to demonstrate connections between it and her teaching behaviors and strategies.

The teacher behaviors and strategies Evelyn used while student teaching were not influenced by behavioral learning theory. It was observed that her behaviors were highly congruent with the social, developmental, and constructivist learning theories. She gave students time to think, she gave them choices, and ultimately her behavior led to a very humane classroom environment where students made their own decisions and took responsibility and ownership of their own actions.

Again, Evelyn did not explicitly articulate connections from learning theory to her teacher behaviors and strategies during student teaching. Evelyn's weak areas in her understandings are her explicit articulations linking learning theory to classroom decisions. Unfortunately these connections drastically weakened from science methods class to student teaching. As shown in Table 30, during science methods, she was able to articulate these connections at a moderate to high level; while student teaching she failed to mention these connections.

Table 30. Evelyn's understandings of learning theories and their connections to effective teacher behaviors and strategies.

	RBF Paper	Oral Defense	Class Observation	Interview
Behaviorism	Absent	Low	Absent	Absent
Constructivism	Moderate	Low	High	Absent
Social	Low	Low	High	Absent
Developmental	Absent	Low	High	Absent

Self-Evaluation. Evelyn did not describe how she would evaluate herself or her program in her RBF paper but during her oral defense, she said that she would use student achievement to decide how successful she was as a teacher in the elementary classroom. This statement shows a low understanding of self-assessment.

While student teaching, Evelyn had a videocamera running. During the interview she did not specifically articulate what she would be looking for on the tape, but she did comment that she realized her nonverbals needed improvement based on previous videotapes. The weakest area for Evelyn is her conception of self-assessment. During

science methods, this was her weakest area; as shown in Table 31, her understandings did not improve over time.

Table 31. Evelyn's understandings of how she will determine if she is a successful teacher.

RBF Paper	Oral Defense	Class Observation	Interview
Absent	Low	Low	Low

Summary of Evelyn's understandings. Evelyn's strengths lie in her explicit and tacit understandings of student goals and the content, materials and activities she will use to meet those goals. While student teaching, Evelyn exhibited some effective teacher behaviors along with a lesson that was consistent with social, constructivism and developmental learning theories. She demonstrated a strong tacit understanding of the components of teaching promoted during science methods class.

Evelyn did not articulate a statement about a learning theory while student teaching. She did; however, make some interesting comments about the RBF process. When asked how the RBF influenced her teaching, Evelyn replied, "If I ever needed to, I could support myself and what I think." (I, 70) "And if parents ever had a problem, I could have something to back me up—research, instead of well, I think they should do this and this." (I, 73-74) She went on to describe how she "had to call a parent...on an issue with a child. And so I can see that I have to be knowledgeable...I have to know what I'm talking about." (I, 90-93) But since she hasn't had to defend herself and her practices, Evelyn describes that she hasn't "had to actually pull out my RBF and use it." (I, 75)

When asked what she learned from the PBL assignment, Evelyn replied, "Now that I am in the classroom, I kind of side more with the teacher in the video because she does have 19 kids and you can't be like awesome all the time...I get how she didn't explain what was going on and she didn't let the kids figure it out...but, in a way I can see also the good things that she did now, too." (I, 128-133) Evelyn continued to discuss the dilemma she has between having students under control and letting them have the freedom to be themselves and learn. She said, "Today, it got super crazy in here. But...what am I going to do?" (I, 143-144) She also commented that, "It's constantly a balance of: Do you want good

classroom management? ... Do you want them all sitting in their body basics and looking at the front of the room? ... Do you want them playing with whatever they are playing with and figuring it out? I don't know. I'm always trying to balance it out and figure it out." (I, 147-151) These comments suggest that Evelyn is struggling with which learning theory is most appropriate for particular learning situations in her classroom.

Student F: Faye

The lesson observed during Faye's student teaching experience was part of a unit on writing in a 5th grade classroom. Unfortunately, Faye was not teaching science during her student teaching placement. As stated earlier in the methodology section, this may limit the richness of these data, but the elements of teaching Faye used to teach writing should be similar to the elements of teaching she would use to teach science. The students sat at desks arranged in groups of four. The students were loud and disruptive while Faye gave directions. She did not expect them to listen to her and later in the lesson it was evident some students did not understand what they were to do. The students were told to create add-on stories. Each student was to take out a piece of paper and write three random, unrelated words at the top of the paper. Faye modeled this idea by writing three words on the board. Each person would be given three minutes to start writing a story. Then students would switch papers. They were to add onto the plot of the new story they received. At some point, all three words at the top of the page were to be incorporated into the story. Students began writing and Faye would keep track of the time. She would tell the students when to switch their papers. While the students switched papers, they would start to talk and get off-task. The students wrote for a half-hour; in that time frame papers were switched several times. Based on the observed student actions, the goals promoted, as written in Faye's RBF paper, were: 1) civic/social responsibility, 2) effective communication, 3) critical thinking, 4) creativity, and 5) conceptual understanding.

Goals. In her paper, Faye did not make references to the interconnections between her goals. She listed her goals in a linear fashion; therefore, as shown in Table 32, they are

coded as absent. Later in her oral defense, Faye articulated a moderate understanding of her link to goals. She chose to discuss the facilitation of the goal of effective communication. She made the statement that the goal of communication goes with a couple other goals, such as self-worth and critical thinking.

The lesson Faye taught promoted five goals simultaneously. Later, in her interview, Faye articulated few goals for her students. Her “goal was to incorporate voice into their writing.” (I, 5) When asked how she has used the RBF, she said, “I’ve been trying to promote...citizenship...which we wrote about in our RBFs and even life-learning.” (I, 73-74) She said she stresses “to [her] kids, [citizenship] is actually a really, really, important part of social studies...because this is...our country, this is where we live. It’s important...because it actually applies to your real life. It’s not just something you learn in school. It’s a role you have as a citizen.” (I, 75-78) Faye also articulated how she has connected math concepts of chance and probability to student’s lives, such as, “games they play...and different stuff [they] do outside of school.” (I, 80-81) A weak area for Faye is her understandings of her student goals and how they all work together. She did refer to them during the student teaching interview, but she did not make the connections between her goals explicit. However, it is encouraging to hear her say she uses her goals for other subjects such as math and social studies.

Table 32. Faye’s understandings of goals and their interactions.

RBF Paper	Oral Defense	Class Observation	Interview
Absent	Moderate	Moderate	Low

Content, Materials and Activities. In her RBF paper, Faye did not mention the content that she would use to promote her student goals and she mentioned the connections between materials and her goals at a very low level. For example, she mentioned, “books, maps, artwork and art supplies, and music all work to encourage creativity.” (P, 15) Even though she vaguely connected these materials to her goals, she made only one reference to materials throughout her paper. She demonstrated a moderate understanding of the connections between activities and her goals. She wrote, “field trips can provide students

with an opportunity to obtain a deep understanding of a concept.” (P, 7) She also wrote, “Writing exercises involve students in thinking critically.” (P, 11) Another connection she made was, “Teachers can foster students’ creativity by giving open-ended assignments.” (P, 14)

During the oral defense, Faye articulated a moderate understanding of the connections between content, materials, and activities and her student goals. She said, “All my goals use cooperative learning because it gets them working together...having self-esteem.” (OD, 243) This was the only high-level articulation made, so overall her oral defense demonstrated a moderate understanding of this component.

Table 33. Faye’s understandings of content, materials and activities and their connections to her student goals and student actions.

RBF Paper	Oral Defense	Class Observation	Interview
Content—Absent Materials—Low Activities—Moderate	Moderate for all 3	Moderate for all 3	High for all 3

As shown in Table 33, the content, materials and activities Faye selected for her student teaching lesson promoted a moderate number of her student goals. During the interview, Faye fully described the content and activities of her lesson. She said, “We’ve been working on adding voice in, which is making it unique to them and making it sound like ...they...talk using descriptive words. I ...thought this would...promote really descriptive words because it would be kind of funny and random with their three initial words they got to pick.” (I, 5-9) Faye wanted students to “carry the plot throughout the story instead of jumping from plot to plot with each person” who started writing on the piece of paper (I, 18-19). Much of Faye’s focus throughout the interview was on content, materials and activities. She said she has a difficult time “finding creative ways to evaluate [students]” (I, 46) because she “really [doesn’t] know what their ability is.” (I, (I, 48) When asked how she might go about determining the abilities of students, she replied, “After I become a teacher, I will do different assignments with them...try new things out...to see how they turn out. And if...they do pretty well on regular assignments using different methods of testing or

assessing...I would be more inclined to use those for more formal assessments.” (I, 54-58) Faye perceives that trial and error would be a legitimate method to determine her content, materials, and activities.

Teacher Behaviors and Strategies. Faye demonstrated low teaching behaviors and strategies throughout her paper. She wrote that teachers should model, promote positive interactions, listen to students, provide encouraging positive feedback, observe student behavior, and group students. She did not connect these strategies to student goals. She also mentioned her teaching behaviors; one example was, “By asking higher order thinking questions and following them with appropriate wait-time, teachers give students an opportunity to challenge themselves to come up with creative answers.” (P, 14-15) Even though this connection is good, she seldom connected her behaviors to her student goals in her paper.

During her oral defense, Faye articulated a moderate understanding of how her behavior and strategies affect student actions. When asked how she would facilitate the goal of effective communication, she immediately responded with two teaching behaviors, questioning and wait time. Later on in the oral defense, she mentioned nonverbal behavior, but struggled to connect it to a change in student behavior. When asked what the value of multiple strategies are, she replied, “To accomplish a goal through a variety of ways” and make it interesting (OD, 77). She also said multiple strategies allow the teacher and students to “work on more than one goal at a time.” (OD, 89)

Faye demonstrated few effective teacher behaviors and strategies during her student teaching lesson. She displayed very passive nonverbals, exhibited little enthusiasm, responded to students in a teacher-directed manner and asked low level thinking questions like the following:

“Do you have a question?”

“Do you have three words?”

“Any other questions?”

“Does anybody have a story in front of them that makes sense?”

“Can I get your attention?”

Many students looked to Faye for affirmation of their word choice. She exhibited some modeling during the directions but failed to elicit student thinking to check their understanding of the activity and assignment. She walked around the room and read student stories while the students were writing.

Faye's explicit understandings were consistent with her implicit understandings. During the interview, she described her role as, "walking around the room, making sure [students] were all participating and staying on-task...Looking over their shoulders to read their stories and helping them come up with ideas of how to start" writing where the last person left off (I, 22-23). She has found the easiest part of teaching is "talking in front of [the] students" (I, 39) and "interacting with them." (I, 42) Her understanding of the teacher's role was coded as low because she sees her behavior as primarily influencing classroom management rather than student learning. Overall as shown in Table 34, Faye's conceptions of her role in the classroom stayed the same from science methods class to student teaching.

Table 34. Faye's understandings of effective teacher behaviors and strategies.

RBF Paper	Oral Defense	Class Observation	Interview
Low	Moderate	Low	Low

Learning Theory and its connection to Content, Materials and Activities. In her RBF paper, Faye used three learning theories to influence her content, materials and activities. Faye had an inaccurate view of developmental learning theory. She wrote, "Students will only be able to learn independently when they are ready; no matter how hard I try, I cannot teach a six year old to take it upon his or herself to learn about the theory of relativity. However, if a person is provided with instruction in developing life-long learning skills, they can learn about such a concept when they have reached a higher level of cognitive maturity." (P, 4) The misconception she has is that students can learn developmentally appropriate concepts independently. Faye also wrote she "must be aware of the different stages students are at and work to design activities that appeal to students at all developmental levels." (P, 6) Again, activities should be selected that are developmentally appropriate, not simply because they appeal to students. Faye also had a low understanding of behavioral learning theory.

She wrote, “[Teachers] can also provide rewards to students after reading a given number of books from different genres to encourage students to explore various kinds of literature.” (P, 14) She made a low connection to constructivism by writing, “Group investigations and the use of Venn diagrams are two ways an outsider could see the constructivist learning theory being used in a classroom.” (P, 17) Again, she wrote another inaccuracy; learning theories are not used in a classroom, instead they influence the decisions teachers make to effectively teach students.

During the oral defense, when asked how she would select her content, materials and activities, Faye used a low understanding of learning theory. Without prompting, she mentioned constructivism, social and developmental learning theory, but her statements demonstrated a low understanding because her statements were either inaccurate or incomplete. She focused on students’ prior knowledge, without articulating why it is so important to do so. She also said it is important to know the level students are at, but failed to articulate why it is important for teachers to know such information. She articulated that social learning theory is important because students want to be social and talk. All of these responses indicate her understanding of these learning theories and their connections to content, materials and activities is rather low.

Table 35. Faye’s understandings of learning theories and their connections to content, materials and activities.

	RBF Paper	Oral Defense	Class Observation	Interview
Behaviorism	Absent	Absent	Low	Absent
Constructivism	Low	Low	Moderate	Absent
Social	Low	Low	Moderate	Absent
Developmental	Low	Low	Moderate	Absent

The lesson Faye taught was developmentally appropriate, promoted student thinking, and required students to work together in an implicit manner. The students had control over what was written, the only stipulation was they write within the context of the already created plot. This suggests that the link to learning theory was high for constructivism, social and developmental learning theories. Behavioral learning theory was minimally reflected in that

students were to follow directions and write using the plot that was created by their fellow students.

Even though her lesson reflected several learning theories, Faye did not articulate these connections during her interview. This is unfortunate because, as shown in Table 35, her explicit understandings of learning theory weakened from science methods class; she is not using learning theory, intentionally, to influence her decisions within the classroom.

Learning Theory and its connection to Teacher Behaviors and Strategies. In her RBF paper, Faye used all four learning theories at a low level to select her teaching behaviors and strategies. Faye wrote, “It is my responsibility to know what stage each of my students is at and to realize if an assignment is too hard or too easy...One way I can help my students out is by grouping them with others in their developmental stage for group work.” (P, 12) An example of her link to constructivism is, “I will also need to monitor the ways my students are thinking and help them to build on what they already know....The behavioral learning theory comes into play as I observe the behaviors of my students. So I can modify my lessons and teaching techniques as needed.” (P, 11) She also wrote, “I will use the social learning theory to model to my students.” (P, 4) Overall, her connections to learning theory were incomplete.

Consistent with her connections in the paper, Faye articulated a low understanding of learning theory and its influence on teacher behaviors and strategies during her oral defense. She said that questioning was good because it promoted deeper student thinking. She also said that many strategies are necessary because students learn differently; what works for one might not work for another. She did not specifically mention a learning theory and its connection to her role in the classroom.

While student teaching, Faye’s behaviors and strategies were moderately influenced by behaviorism. She was looking for specific behavior in her students. Her behaviors and strategies also lowly reflected the other three learning theories. She gave students time to write and expected them to perform at a level appropriate for most 5th grade students.

Even though Faye’s behaviors and strategies reflected learning theories and she made explicit connections during science methods class, she made no reference to learning theories

and how they influence what she does in the classroom during her student teaching interview. These absent connections are shown in Table 36. This is unfortunate because she is not explicitly using learning theory to influence her classroom decisions.

Table 36. Faye's understandings of learning theories and their connections to effective teacher behaviors and strategies.

	RBF Paper	Oral Defense	Class Observation	Interview
Behaviorism	Low	Absent	Moderate	Absent
Constructivism	Low	Low	Low	Absent
Social	Low	Absent	Low	Absent
Developmental	Low	Low	Low	Absent

Self-Evaluation. In her RBF paper, Faye had a high understanding of how she would evaluate herself and her program. Faye wrote, "I will periodically record myself teaching so that I can determine the kinds of questions I pose to my students, how much wait time I give, and how well I use non-verbal communication. I will ask colleagues that I respect as highly effective instructors to watch the recordings of my teaching and provide me with suggestions and feedback. I will also ask for feedback from my students." (P, 17)

Even though she wrote a high understanding of self-evaluation in her paper, as shown in Table 37, during her oral defense Faye articulated a low understanding of self-assessment. She focused on student achievement as a means to evaluate her success as a classroom teacher.

While student teaching Faye did not articulate how she would evaluate herself. She focused on student assessments and how she wanted to assess them. The lack of self-assessment is unfortunate because Faye's understandings of self-assessment could inhibit genuine improvement in her teaching.

Table 37. Faye's understandings of how she will determine if she is a successful teacher.

RBF Paper	Oral Defense	Class Observation	Interview
High	Low	Not Available	Absent

Summary of Faye's Understandings. When asked what recommendations she had for methods instructors, Faye replied, give us more “real-life situations of things that [may] go wrong...instead of just teaching us how to teach” in a certain subject area. She felt that the PBL assignment helped her see the “mistakes teachers make” (I, 124-125) so she will “know not to do that.” (I, 128) Faye also made the comment, “I had about a month off before...I started student teaching” and “didn't think about [the RBF or oral defense]” during the break (I, 101-103). She said, “It would have been nice if I would have like immediately, the next week started working with kids...maybe it would have gelled a little bit more.” (I, 103-105) It could be implied that she didn't think about what it takes to be an effective teacher for a month simply because she wasn't in class or wasn't being forced to think about it. Effective teachers rarely spend time not thinking about education and what they can do to improve classroom instruction.

Faye's strengths lie in her ability to perform in the classroom. The observed lesson promoted some of her goals and she used content, materials and activities that were moderately consistent with developmental, constructivist, and social learning theories. Her explicit understanding of how content, materials and activities influence student actions is another strong component of Faye's understandings and one that improved over time.

Three of Faye's conceptions were not explicit while student teaching. Her connections to learning theory and her use of self-assessment were not evident through her interview comments. Her conceptions of learning theory during science methods were inaccurate and generally at a very low level of understanding, so it is not surprising that they were absent during her student teaching interview.

Student G: Grace

The lesson observed during Grace's student teaching experience was part of a unit on electricity in a 4th grade classroom. The students sat at desks arranged in groups of 3-4 students. On the overhead projector there was a list of directions and the following questions:

How does a B tape affect another B?

How does a T tape affect another T?

How does a B tape affect a T tape? Use the words attract and repel to describe what happens to B and T tapes.

Does the distance seem to make a difference? Try to use the word force in your explanation.

Describe what happens when you increase the distance between the two tapes.

The students had copies of these directions and questions at their desks, also.

Grace asked the initial question, “So what do we notice with the two single pieces of tape?” She modeled how to hold the tapes and walked the students through the first activity to see what a B tape does when held close to another B tape. She asked the students seated in the front to help her with the demonstration. Grace told the students how to do all the tape tests, then she asked, “Am I making that clear?” At the end of her directions she asked, “Does anybody have scissors with them?”

The students proceeded to work in small groups. They followed directions and answered questions on the worksheet. Students demonstrated excitement about the lesson. Several groups deviated from the worksheet and started creating their own tests, using a top tape, middle tape and bottom tape. Some groups simply had fun working with the tapes and didn't really do what was asked on the worksheet. After the allotted time was through, Grace brought the students back together into a large group. She had small groups of students demonstrate the action of the tapes according to the specific questions on their worksheets. Basically, the students demonstrated to the whole class what they recently completed in their small groups. Grace also demonstrated the tests, then she wrote the correct answer on the overhead. During this large group discussion, groups of students disagreed about the action of a set of tapes. One group thought the B and T tapes repelled each other. A few groups thought they attracted each other. A couple groups did not perform that specific test, therefore, had no opinion. Grace told the students what the correct answer was and said, “It could be that they [the tapes] didn't charge right. You're charging them.” The students with misconceptions did not believe Grace; they wanted to test their ideas. Grace told them there would not be enough time for that. This small group immediately crumpled up their tapes and ignored the rest of the discussion. The students were to look at questions 11-14 for

homework. According to Grace’s RBF paper, this lesson promoted the goals of 1) conceptual understanding, 2) critical thinkers, 3) effective communicators, 4) self-worth, and 5) civic and social skills.

Goals. Grace showed a moderate understanding of the connections between her goals in her RBF paper. Near the beginning she wrote, “The division of the goals into separate categories is by no means telling us that they work separately. All the goals are contingent on the success of the other goals and work together to produce a successful educational environment for every student.” (P, 2) She made a few specific comments in her paper also, but missed several opportunities to address other connections. She wrote, “Creating civic and social skills is very similar to developing cultural appreciation and openness to diversity. The four ideas of civic skills, social skills, openness to diversity, and cultural appreciation all work in a cooperative atmosphere.” (P, 3)

As shown in Table 38, during the oral defense Grace articulated a low understanding of her student goals and their interactions. When asked how cooperative learning is connected to her goals, she stated several goals, such as self-worth, communication, diversity, and literacy, and explained the influence cooperative learning has on these goals. This connection was coded as low because Grace required prompting to make the connections.

Table 38. Grace’s understandings of goals and their interactions.

RBF Paper	Oral Defense	Class Observation	Interview
Moderate	Low	Moderate	Low

The lesson Grace taught promoted some of her student goals. Even though she promoted five goals through her lesson, during the interview, Grace articulated few goals for her students. She wanted them to “test out the pieces of tape” for her lesson on static electricity (I, 6). She focused heavily on the goal of content, articulating that students should “[find] the different reactions that happen between the B and the T tapes and what happens [between] a T and a T” tape (I, 10-11). She wanted her students to make “observations and [be] able to use the words attract and repel to describe” the behavior of the tapes (I, 12). She

vaguely articulated two other goals for her students. She wanted to “get them to be a little more independent” (I, 8) and get them “motivat[ed] to work with all four” people in their group (I, 26). Overall, these statements describe a low understanding of goals and their connections.

Content, Materials and Activities. In her RBF paper, Grace described a low understanding of the connections between content and her student goals. She listed a few ideas about the content she would select. Teachers should “include lessons on how to convey self worth to others,” (P, 6) and choose “content to fit real work scenarios.” (P, 9) She also wrote that schooling should “teach students about holidays, events, and heroes of different cultures.” (P, 18)

She described a moderate understanding of using materials to meet her student goals. On page 11 she wrote, “materials are an essential part to building and applying learning. It is essential to use hands-on materials and not just a textbook to support ideas taught.” For the goal of creativity she wrote, “Using materials that promote real work experience will enhance the effort and creativity that students put into their work...Hands-on learning materials...need to be...creative.” (P, 21)

Grace also had a moderate understanding of how activities promote her goals. On page 13 she wrote, “Effective communication is a key part of the field of science...It is also essential that students be given the opportunities to work with and brainstorm with others to come up with the ultimate solutions...Activities to enhance this skill are paraphrasing sessions, debates, presentation, group work, partner work, and discussions.” For a different goal she wrote, “Critical thinking skills promote communication and challenge students to encompass all student ideas to answer a question. Materials, content and activities should promote this in the classroom.” (P, 15)

During her oral defense, Grace articulated a low understanding of content, materials and activities and their connection to student actions and goals. When asked how she would select her content, materials or activities, Grace responded with several general comments or strategies. Unfortunately, she only made connections to her goals when explicitly directed to do so.

The lesson Grace planned had content, materials and activities that promoted a moderate number of student goals. After the lesson, during her interview, Grace described several student actions that would show evidence of her goals. She wanted students to “[be] able to make [the tape]” (I, 5), “[ask her] a ton of questions” (I, 16), “[talk] about” (I, 17) the activity, stay “on task” (I, 17), “write [their ideas] in the packet” (I, 20), “work with all four” people in their group (I, 26), “[interact] with the materials” (I, 49), and use “the words attract and repel to describe” the behavior of the tapes (I, 12). The content, materials and activities articulated fully promoted the goals and student actions Grace described. Overall, as shown in Table 39, Grace’s understandings of this element of teaching became stronger while student teaching.

Table 39. Grace’s understandings of content, materials and activities and their connections to student goals and student actions.

RBF Paper	Oral Defense	Class Observation	Interview
Content—Low Materials—Moderate Activities--Moderate	Low for all 3	Moderate for all 3	High for all 3

Teaching Behaviors and Strategies. Grace also referred to her teaching behaviors and strategies at a low level in her RBF paper. The following are teaching strategies that she mentioned in her paper; teachers should: “model,” (P, 3) “observe the behaviors of students,” (P, 3) “monitor student thinking,” (P, 7) “create environments conducive to open and accepted interaction,” (P, 7) show “enthusiasm,” (P, 20) and “give students feedback.” (P, 24) Grace also described teacher behaviors in her paper. Teachers should use “higher order thinking questions [to]...draw out more in-depth thinking and communication to others.” (P, 7) On page 13 she wrote, “Verbal tones can be very influential on the amount a student will feel comfortable communicating in the classroom.” She also mentioned the “importance of eye contact and body positioning in the ability to create an environment for students that is open and communicative, (P, 14) as well as “body proximity, wait time and

eye contact.” (P, 15) Even though she vaguely connected her behavior with the promotion of student goals, she missed several opportunities in her paper to make more connections.

During her oral defense, Grace articulated a low understanding of teaching behaviors and strategies. When asked how she would facilitate her goal of self-worth, Grace did not articulate any teacher behaviors. Later in the defense, she articulated nonverbals and open-ended questions, in the context of behaviors useful to facilitate a class discussion.

Consistent with her explicit understandings from science methods class, while student teaching, Grace demonstrated a low understanding of teacher behaviors and strategies. Her predominant questioning pattern was a yes/no question or short answer question. She had poor wait time after asking a question. Then, she responded to students by repeating their comments. The questions Grace asked of students during small group work were predominantly used for classroom management rather than student thinking. Rarely did she ask questions to elicit or promote student thinking. During the class discussion several opportunities arose to promote thinking and testing of ideas, but she missed them because she was focused on getting through the lesson in the allotted time period. Throughout the lesson, it became apparent that she was looking for students to say attract and repel in the right situation. At the very end of the lesson she asked two thought provoking questions. “Why do you think they are coming together?” and “What is common between B and B and T and T tapes?” Even though her questioning and responding patterns need work, Grace used her nonverbal behaviors effectively most of the time.

As shown in Table 40, during the interview Grace articulated a moderate understanding of teaching behaviors and actions. When asked what evidence she had the students were meeting her goals, she replied, “I’ll be observing them as I go around and just listening in on their conversations.” (I, 16-17) She stated that she writes student answers on the overhead because students “don’t write [them] down in [their] packet[s].” (18-19) She “ask[s] them probing questions” to “[get] them to respond with more in-depth ideas on what [they’ve seen] happen.” (I, 31-32) She articulates an example of a question she might ask to get her students thinking; “Why do you think they’re going apart?” (I, 33). Grace also articulated that “body proximity” can be a way “to get kids to talk to each other instead of” always talking to her (I, 85). These statements demonstrate that she understands how the

teacher behavior articulated can be used to promote specific student actions. During her student teaching experience, Grace articulated a higher understanding of her teacher behaviors than she was able to implicitly demonstrate.

Table 40. Grace's understandings of effective teacher behaviors and strategies.

RBF Paper	Oral Defense	Class Observation	Interview
Low	Low	Low	Moderate

Learning Theory and its connection to Content, Materials and Activities. In her RBF paper, Grace used constructivism sparsely to select her content, materials and activities; therefore this connection is coded as low. Portfolios are “an easy way to see if a student is successfully building on their prior knowledge base and applying what has been learned.” (P, 11) The teacher should “set up classroom activities that require students to use previous knowledge in a new context.” (P, 11)

Grace also used developmental learning theory quite frequently within her paper. On page 4 she wrote, “Materials and content chosen by the teacher must be appropriate for the age level of the students.” She also wrote, “The content taught to any given student must be adequate to their grade level in order to enhance their ability to discover and communicate with others.” (P, 13) These statements are vague, but not incorrect. However, on page 15 Grace made an interesting comment, “Content should be developmentally appropriate according to standards given at the school.” This statement implies that she does not understand developmental issues accurately because school standards are not always developmentally appropriate; therefore, she is coded low for her developmental learning connection.

Grace only used behaviorism once to support her content, materials and activities selection. On page 4 she wrote, “Awareness of prior knowledge and behavior encourages the teacher to implement sessions of feedback to help the child grow....In the case of improving social and civic ideas there is room for use of rewards.” This connection conveyed a low understanding.

Consistent with her RBF paper, in her oral defense, Grace used the developmental and constructivist learning theories at a low level to select her content, materials, and activities. She only referred to these theories when explicitly prompted to do so, or given a very concrete situation with which to think and respond. When questioned about her use of cooperative groups, she replied, “Kids need to talk things out. They have preconceptions and may change their ideas” by talking with others (OD, 567). Grace did not mention the behavioral or social learning theories during her oral defense.

As shown in Table 41, the implicit connections Grace made were generally higher than the connections she explicitly made during science methods class. The content, materials and activities moderately reflected the social, constructivist, and behavioral learning theories. The content was developmentally inappropriate for most 4th graders, therefore her link to developmental learning theory is absent. The activity had the potential to promote student thinking and address misconceptions, however, the teacher behaviors highly reduced these outcomes. The students were working in groups and cooperating together; again, the teacher behaviors reduced the effectiveness of this component of the lesson. Her behaviors were primarily used for classroom management rather than student thinking. She asked low level questions and failed to effectively engage some of the groups in the classroom. The content, materials, and activities were moderately influenced by behavioral learning theory also. The students followed directions and answered questions. Unfortunately, the students’ level of understanding was centered on the correct use of vocabulary such as repel and attract.

Even though Grace’s lesson demonstrated an absent developmental learning theory connection, she articulated a high understanding of developmental learning theory during her student teaching interview. When asked about the PBL assignment and what she learned from it, Grace made the comment, “of course the material was way too advanced for those kids.” (I, 175-176) This led into a discussion of the lesson she taught. Grace articulated, “I don’t necessarily think what the 4th graders were learning was at their level because they were struggling ... to explain” it (I, 183-184). It was a “struggle to get them to understand what they couldn’t see.” (I, 185) She went on to explain her thinking in great depth; “There was something happening that they couldn’t see [and] they couldn’t quite understand. When

we got into talking about...positive and negative charges and all that stuff, they didn't understand quite how that was working. They understood that something was happening there...you can see something happening, but you don't really understand why it is happening. So I think that was the biggest problem with teaching electricity." (I, 188-193) She described students as understanding "that opposites...attract and similar charges repel...They just didn't understand the positive and negative." Grace feels that her students "wouldn't be able to apply" their knowledge of electricity to a new situation (I, 228). Grace also indirectly referred to behaviorism by saying, "and once we went over it four to five days in a row, they could repeat it back to [me], but I don't think they under[stood]" (I, 222-225). It is encouraging to hear Grace articulate the difference between memorized information and conceptual understanding.

Table 41. Grace's understandings of learning theories and their connections to content, materials and activities.

	RBF Paper	Oral Defense	Class Observation	Interview
Behaviorism	Low	Absent	Moderate	Low
Constructivism	Low	Low	Moderate	Absent
Social	Absent	Absent	Moderate	Absent
Developmental	Low	Low	Absent	High

Even though Grace knew the content she taught was developmentally too advanced for 4th graders, she taught it anyway. Constraints are placed upon student teachers and the particular school district she was placed in had electricity "written right into" the curriculum (I, 202). The benchmarks for this unit were: Students will "demonstrate static electricity, develop an open and closed circuit, identify parts of an atom, explain the difference between current and static electricity, identify the effects of electricity on every day life and compare and contrast parallel circuits and series circuits." (I, 205-208) Grace did not demonstrate any willingness to go against the system, or possibly get the benchmarks changed, but this is virtually impossible to do as a student teacher. She said, "if you have to teach it for the school district, then you have to teach it...but it's ...very frustrating." (I, 231-232)

These comments are consistent with the statement she made in her RBF paper; however, it is important to realize that student teachers are in a situation where they want to please their cooperating teacher, principal and university supervisor. At this point it is unknown whether Grace would change the content if she had her own classroom.

Learning Theory and its connection to Teacher Behaviors and Strategies. In her RBF paper, Grace used constructivism at a moderate level to influence her teaching behaviors and strategies. Higher order thinking questions are used to “draw out more in-depth thinking.” (P, 7) “Observing students and recording their actions...[would] give the teacher the background knowledge to be aware of student interests and potential as well as where they are in their learning process.” (P, 9) Teachers also need to “monitor [their] students’ thinking in order to adequately build on students’ previous knowledge.” (P, 12) On page 4 she wrote, “It is important to analyze a student’s prior knowledge about social skills by asking questions, listening to students and observing their behavior...Awareness of prior knowledge and behavior encourages the teacher to implement sessions of feedback to help the child grow.”

Grace also used social learning theory at a low level to influence her teaching behaviors and strategies. On page 14 she wrote, “Social learning theory values the importance of eye contact and body positioning...This ties in with the ability to interpret your students and their needs.” The statements connecting the teacher’s role to social learning theory were vague at best and occurred infrequently.

During her oral defense, Grace did not explicitly connect learning theory to her teaching behaviors and strategies. When asked why multiple strategies are useful, she replied, “Not every strategy works for every student because they have different learning styles.” (OD, 250) Rather than linking her use of questioning with learning theory when defending her practice of responding to student questions with another question, she said it is good for the students to struggle. She also replied that questions promote student thinking, but did not elaborate upon this idea. Overall, her connections for this link are low.

While student teaching, Grace’s teaching behaviors and strategies were moderately influenced by behavioral learning theory. She repeated student comments, and asked low

level questions. She wanted students to use vocabulary words correctly. These behaviors reflect behavioral learning theory because they promote students to focus on the teacher's actions and statements rather than on students' actions and ideas. Her teaching behaviors reduced the effectiveness of the materials and activities because she did too much of the thinking for the students. Her behaviors minimally reflected the other three theories. She did expect students to work together and wanted them to explore the ideas of repulsion and attraction but her behaviors did not convey this idea all of the time. Unfortunately, Grace did not connect her behaviors to any learning theories during her student teaching interview. As shown in Table 42, her understandings for this element of teaching weakened over time.

Table 42. Grace's understandings of learning theories and their connections to effective teacher behaviors and strategies.

	RBF Paper	Oral Defense	Class Observation	Interview
Behaviorism	Absent	Absent	Moderate	Absent
Constructivism	Moderate	Low	Low	Absent
Social	Low	Absent	Low	Absent
Developmental	Absent	Low	Low	Absent

Self-Evaluation. Grace had a moderate understanding of how to assess herself and her program in her RBF paper. She wrote that teachers should “tape” themselves and keep a “private journal that will help [them] rethink actions demonstrated through out the day.” (P, 9)

In her oral defense, Grace had a low understanding of self-assessment. She articulated that she would use student achievement and ask any colleague or administrator to observe her teaching. The combination of the two should help her decide if she is a successful teacher, but she totally left out the component of self-assessment.

Table 43. Grace's understandings of how she will determine if she is a successful teacher.

RBF Paper	Oral Defense	Class Observation	Interview
Moderate	Low	Not Available	Moderate

During her student teaching interview, when asked how the RBF influenced her teaching, she replied, “The first week, I think I forgot it all.” (I, 61). But she goes on to qualify this statement. She describes how difficult student teaching is because she has “so many things going on in[side my] head.” (I, 61-62) She commented that she has goals for herself when she teaches and believes that there are things that she has “really mastered” (I, 64), but she is not where she wants to be because she “want[s] to be able to [have good teaching behaviors] all the time.” (I, 64) She describes how her “questioning skills...wait time...[and] body proximity [are] not there for [me] yet.” (I, 66-68) She is “aware of those things” but struggles to “[implement] them.” (I, 68-69) She comments, “reminding myself that I need to smile and do all those little things in between is really hard for me. I’m struggling with that. I’m trying to get it all in.” (I, 41-42) These statements are encouraging. Grace articulates where she perceives her current teaching behaviors are, and also has a clear picture in mind of what she would like them to eventually be. Her explicit knowledge of teaching behaviors should help her manipulate her own actions in order to improve her teaching. Grace made several comments on self-analysis of her teaching behaviors, which is much stronger than either her RBF paper or her oral defense.

Grace made other comments during the interview that suggest her ideas of self-assessment, as shown in Table 42, became stronger over time. She said what she learned from the PBL assignment was how to “evaluate what’s going on, so [I] know [I] could go back and start evaluating myself and what I do.” (I, 172-173) She elaborated upon this by saying that she should be “able to watch something close enough to evaluate it and look at it and find what worked, what didn’t work and why things were going on.” (I, 173-175)

Grace also articulated interesting comments on the RBF paper. She said, “I wrote it on the premise of like a fantasy world of what I [thought] teaching was going to be like. I didn’t write it for all the curveballs ... that come at you when you’re teaching. So, it’s a lot harder in real life to implement what you wrote. It doesn’t mean it’s impossible, it just means you have to get more experience at what you’re doing... I thought it would be a cake-walk to be able to do some of those things that I had in my paper and it’s not that easy. I mean you have different reactions coming at you every day; something might work one day and it doesn’t work another day.” (I, 95-101) The RBF paper is theoretical in nature and it

will take thoughtful practice to develop the expertise to implement all the ideas effectively and simultaneously. Grace shows evidence of understanding this; “I’m sure eventually when I get to the point where I’m really developed and know exactly what I want for my class, [the RBF] will work.” (I, 103-105)

Summary of Grace’s Understandings. Grace has several strengths and can articulate her weaknesses accurately. Grace planned a good lesson that utilized several of her student goals. Her great strength is in her ability to articulate her knowledge of how content, materials and activities influence student actions, how the content connects with developmental learning theory, teacher behaviors, and self-evaluation. The lesson she taught was developmentally inappropriate for most 4th grade students and she knew it. She was able to explain why her students did not understand the material. She believed the content must be taught because it was part of the school district’s expectations. This particular misconception also surfaced in her RBF paper. Her conceptions of developmental learning theory and its connection to content were much stronger during student teaching than they were during science methods class. Her ability to describe the content, materials and activities and how they influence student actions to get to student goals was also stronger during student teaching than during science methods. This increase in understanding could be due to experience and thoughtful practice. It could also be due to wrestling with some of the issues discussed in class, such as the developmentally inappropriate content and trying to determine what course of action should be taken.

The teacher behaviors that Grace articulated while student teaching were connected to self-assessment. She explained what she wanted to do, or what she should do, and then qualified her comments by saying she knows her teacher behaviors are not where they should be and she needs to work on them. She articulated some very thoughtful comments on how complex teaching is. She admitted that she doesn’t think about the RBF all the time because she has so many things to think about while student teaching.

Areas where Grace did not show improvement were her conceptions of her student goals and her connection between teacher behaviors and learning theory. Unfortunately, both these areas decreased in understanding over time.

Student H: Holly

The lesson observed during Holly's student teaching experience was not part of a unit. It was a lesson placed in-between units within a kindergarten classroom. The students were seated at circular tables in groups of five. To begin, Holly tried to get them to sit still and listen. She said things like, "John is sitting quietly. Susie is paying attention." Holly asked the children, "Who knows what an iguana is?" Then, she read a book about iguanas. During the book reading, students would raise their hands to share something they knew that was related to the story. One student commented that the iguana changed colors to match its environment. Students also asked a lot of questions during the story. So many student comments and questions were posed that only half the book was read during the lesson. During the lesson, Holly frequently reminded students to sit in their body basics. After the book reading, the teacher's aide came into the room with her pet iguana, Martine. Holly told the students, "We have to be quiet, otherwise the iguana will get scared." Immediately, the students became quiet and interested in the iguana. The teacher's aide told the students about her pet: what he ate, where he lived, how he sheds, how much he sleeps, how she bathes him, how long she has had him and what he does when he is hungry, angry, or scared. The students had many questions for the teacher's aide, some of which were: "Was he in an egg?" "What is that thing?" "Can we touch him?" At the end of the lesson, students could touch the iguana. The goals promoted by this lesson, as written in Holly's RBF paper were: 1) effective communication, 2) civic/social responsibility, 3) self-worth, critical thinking, 4) literacy/literacy appreciation, and 5) conceptual understanding.

Goals. During science methods class, Holly showed no understanding of the interconnections between her student goals. In her RBF paper, she wrote the goals in a linear and disconnected fashion; during the oral defense, she used one goal at a time, failing to mention how the promotion of some goals affect the promotion of other goals.

Even though Holly did not articulate her goals and their connections, her student teaching lesson promoted several of the student goals she had listed in her RBF paper. During the interview, when asked what goals she has for her students, Holly replied the

lesson was “an introduction to reptiles.” (I, 5) When asked how the RBF has influenced her teaching, she responded that the ten goals she had “helped [her] to know...what’s important.” (I, 85-86) She said, “I don’t want to say I think about them everyday” (I, 83) and “I haven’t really done anything with them.” (I, 89) She articulated that she has “been worried about getting done what [her] teacher needs [her] to do and what [her] supervisor needs to see” so she hasn’t placed much emphasis on her goals (I, 105-106). She did mention, “I constantly think” about the goal “being effective communicators.” (I, 94) She said she thinks about whether students “need to work in a small group, or...a large group.” (I, 95-96) She also tries to get the kindergarteners to “articulate their thoughts.” (I, 97)

Overall as shown in Table 44, Holly’s explicit understandings of goals did not change from science methods class to student teaching. During the interview, she mentioned some goals but still did not articulate connections between goals. It seems as though her implicit knowledge of goals is far higher than her explicit understanding.

Table 44. Holly’s understandings of goals and their interactions.

RBF Paper	Oral Defense	Class Observation	Interview
Absent	Absent	High	Low

Content, Materials and Activities. In her RBF paper, Holly wrote a low understanding of how her content, materials and activities influenced her student goals. She focused on activities in her paper and made vague connections to her goals in only a few instances. For example, “In a classroom of effective communicators you would see students working cooperatively in groups, giving oral presentations, sharing their feelings about other students’ work as well as their own, and doing a lot of oral reading in class.” (P, 6) Materials were mentioned once and were vaguely connected to her student goals. Holly wrote, “The room needs to have a wide variety of manipulatives so that students can work with these to further their creativity. The teacher should have the following in the room: construction paper, glue, scissors, puppets, tape players, plates, pipe cleaners, tissue paper, paints, clay old clothes, a variety of literature, a variety of magazines, books, newspapers, etc.” (P, 31) Holly also stated content that would be useful, but did not explicitly connect it to her student goals.

She wrote, “Topics covered in the lessons should be self-concept, ethnic and national heritage, the significance of names, social roles, national games, folk tales, interdependence and special education.” (P, 22) Overwhelmingly, throughout her paper Holly focused on activities and occasionally made explicit connections between her student goals and the activities she had chosen.

Consistent with her RBF paper, during the oral defense, Holly did not make explicit connections between her goals and the content, materials or activities she selected. At best, the link was implicit; therefore as shown in Table 45, this element is coded as low.

However, the lesson Holly taught while student teaching demonstrated a high understanding of student goals because the lesson promoted several goals simultaneously, which was partly the result of the content, materials and activities selected. During the student teaching interview, Holly accurately articulated the content, materials and activities of the lesson and how they impacted the student actions observed. Holly wanted her students to realize that iguanas are reptiles, not mammals. Since her lesson was an introduction, she wanted to “find out what [students] knew about iguanas.” (I, 25-26) The students “listened” (I, 24) to a book about iguanas and “discuss[ed]” what they knew about them also (I, 25). Holly seemed to have stronger sense of what activities were needed to promote her goals during student teaching because she gave more specific connections and concrete examples.

Table 45. Holly’s understanding of content, materials and activities and their connections to student goals.

RBF Paper	Oral Defense	Class Observation	Interview
Low	Low	High	High

Teacher Behaviors and Strategies. Holly demonstrated low understandings of both her teaching behaviors and strategies throughout the RBF paper. She wrote, “To be effective communicators, ...teachers must be skilled at listening, asking questions, paraphrasing, agreeing and disagreeing, describing behavior and feelings, checking perceptions, and providing feedback.” (P, 4) Throughout most of the paper, Holly lists a variety of teaching strategies that she finds useful without describing why they are important or how they

promote her goals. She mentioned that teachers should be “respectful” and “model everything in the way” they want their students to do things (P, 5). Teachers should also “provide support,” give “student feedback and observe student behavior.” (P, 14)

Throughout the entire paper, Holly only briefly mentioned one teaching behavior; she will use “questioning” with her students (P, 5).

During the oral defense, Holly accurately stated how her understandings of teaching behaviors and strategies were her weakest component of teaching. Throughout the defense, she focused on the strategy of modeling. Initially, she did not articulate any teaching behaviors. When asked what her role was in a class discussion, she replied with several nonverbals, such as proximity, walking around, facial expressions, posture, and eye contact. She also said it would be good to wait. Overall, her understanding of the connection of this element of teaching to student goals is low because she missed opportunities to explain her role in the classroom and when she did it took prompting to get her to articulate her teaching behaviors.

As shown in Table 46, Holly exhibited a moderate understanding of teaching behaviors during her student teaching lesson. She does some things well, but needs improvement in her questioning and responding patterns. Holly asked some thought-provoking questions of her students; however, the majority were short answer or yes/no questions. Some examples of her questions are, “What does territorial mean? Does anyone else know what territorial means? What other animal does this sound like that we’ve studied?” After asking a question, Holly demonstrated effective wait time I. After the student response, Holly tended to repeat the student and give immediate praise. Her nonverbals conveyed enthusiasm and were appropriate for the lesson. She also used her nonverbals to manage student behavior. She utilized the strategy of modeling within her lesson. During the second half of the lesson, Holly sat by a special needs student who was scared of the iguana. This student needed a lot of affirmation and consoling in order to stay in the room while the iguana was there.

During the student teaching interview, when asked what her role was, Holly replied, “I was...the...role. It wasn’t like they explore[d] their own learning...I was the facilitator of the knowledge.” (I, 20-21) She went on to say that she “read” a book while the students

“listened.” (I, 24) She also said, “I asked them questions...Is the iguana a mammal? Is it a reptile? How can you tell?... We talked more about the specific differences between an iguana and a mammal.” (I, 10-13) Holly said that the easiest part of teaching for her was “leading discussions” and “getting [students] thinking.” (I, 56-67) Later in the interview, when asked how well science methods class prepared her for teaching, Holly replied, “I never would have before that class thought about my wait time...or my body movements... Things like that I’ve just worked on...and I constantly think about now.” (I, 126-128) Holly made several references to teaching behaviors but she did not explicitly connect them to student actions or goals. The behaviors and strategies she did mention were rather vague and didn’t describe her role in the classroom specifically.

Table 46. Holly’s understandings of effective teacher behaviors and strategies.

RBF Paper	Oral Defense	Class Observation	Interview
Low	Low	Moderate	Low

Learning Theory and its connection to Content, Materials and Activities. In her RBF paper, Holly used behavioral learning theory at a moderate level of understanding. For example, she wrote, “The teacher can give rewards and punishments for students who are being effective communicators and those who aren’t.” (P, 7) She also used developmental learning theory at moderate level of understanding. On page 29 she wrote, “The teacher needs to developmentally know what level his students are at so he can offer developmentally appropriate activities.” Holly also used constructivism at a moderate level of understanding. She wrote, “Teachers have to know where their students are before starting a new concept.” (P, 33) She went on to say, “It is very important for the teacher to choose activities based on the student’s prior knowledge.” (P, 34) All of these connections were coded as moderate because they were rather vague or definitional in character.

During the oral defense, Holly’s understandings of learning theory and its connection to content, materials and activities weakened. When prompted with a specific context and situation, she gave a moderate understanding of developmental learning theory. When defending her practice of cooperative grouping, she articulated a low explanation based on

rules. Because Holly only articulated connections to learning theory when prompted to do so, her overall understanding of this link is low.

The content, materials and activities observed during her student teaching lesson moderately reflected the behavioral learning theory. Students were told about iguanas through the book reading and the teacher's aide. The lesson also moderately reflected the social, developmental, and constructivist learning theories. The lesson was developmentally appropriate for most kindergarteners. The students thought about iguanas and were encouraged to ask questions and share their ideas. They learned more about iguanas from the whole class interaction. The ideas and questions students brought up made it evident they were thinking and very interested in this reptile.

Even though Holly's lesson moderately reflected all four learning theories, unfortunately, she was unable to articulate those connections during the interview following her lesson. Overall as shown in Table 47, Holly's explicit understandings of the connections to learning theory weakened from science methods to student teaching. But it is encouraging to see her demonstrate some tacit knowledge of the learning theories and how they influence her lesson.

Table 47. Holly's understandings of learning theories and their connections to content, materials and activities.

	RBF Paper	Oral Defense	Class Observation	Interview
Behaviorism	Moderate	Absent	Moderate	Absent
Constructivism	Moderate	Absent	Moderate	Absent
Social	Absent	Low	Moderate	Absent
Developmental	Moderate	Moderate	Moderate	Absent

Learning Theory and its connection to Teacher Behaviors and Strategies. In her RBF paper, Holly displayed low understandings of using two learning theories to influence her teaching behaviors and strategies. Holly made several references to social learning theory but left out critical components of the theory. She wrote, "The teacher is modeling the behavior and should be challenging the students to apply their knowledge, which

incorporates the social learning theory.” (P, 20) Her connections to constructivism also showed low understanding. She wrote, “The teacher’s role is definitely to monitor the students thinking and see if they are making the right connections.” (P, 26) This one statement is correct, but she is missing other critical components of the theory.

During the oral defense, her understanding of teaching behaviors and strategies and their connection to learning theories was low, at best. She felt that multiple strategies would be beneficial because students would not get bored. Later, when defending the practice of responding to a student question with another question, she articulated that questions promote deeper student thinking. This statement implied the influence of constructivism, but she made no explicit references to a particular learning theory.

The teaching behaviors and strategies Holly used during her student teaching lesson moderately reflected the social, developmental and constructivist learning theories. She wanted students to talk about their questions and ideas; she conveyed this through interested nonverbals and wait time. But then she responded to student comments in a very teacher-centered manner. She sent a mixed message because her behaviors and strategies were also moderately influenced by the behavioral learning theory. She used her behaviors to get students to sit in their body basics and listen to the reading of the book. Her responses to students sometimes conveyed that she was looking for a particular word. She would also restate or clarify what a student had said to get her point across. Overall, Holly displayed behavioral strategies about half the time.

Table 48. Holly’s understandings of learning theories and their connections to effective teacher behaviors and strategies.

	RBF Paper	Oral Defense	Class Observation	Interview
Behaviorism	Absent	Absent	Moderate	Absent
Constructivism	Low	Low	Moderate	Absent
Social	Low	Absent	Moderate	Absent
Developmental	Absent	Absent	Moderate	Absent

Even though Holly demonstrated some effective teacher behaviors, as shown in Table 48, her explicit connections and links from and to learning theory diminished over time. She

started with low to moderate understandings, but while student teaching failed to mention any connections from learning theory to her observed lesson.

Self-Evaluation. As shown in Table 49, Holly did not address how she would evaluate herself or her program in her RBF paper. Then during her oral defense, she stated a low understanding of self-assessment. She said that she would ask any colleague or administrator to evaluate her performance as a classroom teacher. She still did not understand the need for self-assessment. Consistent with these understandings at the end of science methods, while student teaching, she did not mention self-assessment during her interview.

Table 49. Holly's understandings of how she will determine her success as a teacher.

RBF Paper	Oral Defense	Class Observation	Interview
Absent	Low	Not Available	Absent

Summary of Holly's Understandings. Holly did not make any statement about learning theories. She did; however, make an interesting comment about the RBF. Holly said, "I feel like I would focus on [the RBF] more...in my fourth grade [class]...I don't really...think it applies as well to kindergarten." (I, 110-111) She justifies her comment by saying, "I can't let [kindergarteners] explore as much" as I could students in "a higher grade." (I, 117) Unfortunately, Holly feels that the age of the students limits the usefulness of the RBF.

When asked about the usefulness of the PBL assignment, Holly replied, "Well, from watching the bad video...it...showed me...how I don't want to be." (I, 141) She went on to say, "You can be teaching a great lesson, [and] if you don't teach it in the right way, you can still screw it up." (I, 142-143)

Holly's strengths lie in her ability to use her tacit knowledge in the classroom. The lesson observed during student teaching demonstrated moderate to high tacit understandings of the RBF schematic from science methods class. Another strength Holly possesses is her

ability to articulate the content, materials and activities and how they affect her students' actions. This part of the schematic became stronger while Holly student taught.

Holly's conceptions of her goals, teacher behaviors, and self-evaluation did not change from science methods class to student teaching. During science methods class, Holly did not articulate connections between her goals; while student teaching she mentioned some goals, but did not articulate any connections between them. Her articulations about teaching behaviors are lower in understanding than what she tacitly demonstrated. Holly mentions the behaviors very broadly, but does not connect them with student actions, or articulate them explicitly. Holly articulated very low understandings of self-assessment during science methods and failed to articulate any understanding of the piece while student teaching.

Chapter 5. Discussion and Implications

The purpose of this study was to determine what effects, if any, PBL had on preservice teachers' conceptions of teaching and learning at the end of a science methods course and while student teaching. Overall, the combination of a PBL experience embedded within an RBF science methods course had more positive results on preservice teachers' understandings of teaching and learning than an RBF science methods course alone. These positive results were seen both at the end of the science methods course and during the student teaching semester. While generalizations are limited based on these findings, the four students who had the PBL and RBF assignments demonstrated and articulated more robust understandings of teaching and learning, particularly in areas where the PBL videotape was discrepant. Specifically, their understandings of student goals, teacher behaviors and strategies, developmental learning theory, and self-evaluation were of greater depth while student teaching than those four students who only had an RBF experience and a traditional unit plan assignment. This chapter will summarize and discuss each element of instruction (goals, content, materials and activities, teacher behaviors, learning theory, and self-evaluation) and describe the similarities and differences in understandings between the two groups of participants.

The conclusions presented in this chapter present a large challenge to teacher educators. Even though some positive articulations were made, unfortunately, all eight students' explicit conceptions of learning and teaching weakened from science methods class to student teaching. The implications of this study are fivefold. First, this study reinforces the importance the PBL problem has on what is learned by the students. Second, this study reinforces the idea that teaching is a complex endeavor and learning to teach effectively is a complicated process. Third, emphasis is placed on the importance of the cooperating teacher for further student teacher development. Fourth, this chapter argues that one course using the RBF is not enough; elementary teachers need more time to undergo conceptual change of these complex ideas related to teaching and learning. Fifth, longitudinal studies are needed to determine the effect PBL embedded with an RBF classroom would have on professional teachers' practice and understanding of teaching and learning.

Elements of Effective Instruction

Goals

As shown in Table 50, at the end of science methods class the PBL group articulated better connections between their goals than the non-PBL group. Consistent with this trend, all members of the PBL group articulated more than just the goal of content while student teaching. This is encouraging because the preservice teachers have goals for their students, they can articulate them, and the goals were implicitly promoted during the student teaching lessons, which is far better than the findings Goodlad (1983) reported.

Table 50. Summary of all eight participants' understandings of goals.

Class A Non-PBL					Class B PBL				
	RBF Paper	Oral Defense	Class Observation	Interview		RBF Paper	Oral Defense	Class Observation	Interview
A	Absent	Absent	High	Absent	E	<i>Moderate</i>	<i>Moderate</i>	<i>High</i>	<i>Low</i>
B	Absent	Absent	Moderate	Low	F	<i>Absent</i>	<i>Moderate</i>	<i>Moderate</i>	<i>Low</i>
C	<i>High</i>	<i>Moderate</i>	<i>Absent</i>	<i>Low</i>	G	Moderate	Low	Moderate	Low
D	<i>Low</i>	<i>Absent</i>	<i>Moderate</i>	<i>Absent</i>	H	Absent	Absent	High	Low

* Italics denote a decrease in explicit understandings. Bold indicates an increase in explicit understandings.

The reason the PBL group articulated more explicit goal statements is not known for sure. Olson (2002) did not find any statistical difference between the PBL group and non-PBL group and their articulation of student goals during the science methods oral defense. One possible reason could be time. The non-PBL students waited three to four months after science methods before they began student teaching due to summer break, while the PBL group only had one month of leave between methods and student teaching. Even though time could be a factor, it is intended that all student teachers use the knowledge they gained in their preservice program to inform their teaching in schools.

Even though preservice students articulated some goals during student teaching, all students' explicit understandings of this element of effective teaching decreased from science methods class to student teaching. Even though the lessons observed during student teaching promoted some student goals, if the student teacher did not articulate goals specifically, it is

not known whether the student teacher was deliberately promoting the goal, or if the goal was promoted by mere coincidence.

Content, Materials and Activities

At the end of science methods, no difference existed between the two groups; they both articulated higher connections between activities and student actions than either links from content or materials to student actions. While student teaching, both groups again focused more on activities than content or materials. Encouragingly, as shown in Table 51, all study participants' explicit understandings of these links either stayed the same or became stronger than those expressed during science methods.

Table 51. Summary of all participants' understandings of content, materials and activities.

Class A Non-PBL					Class B PBL				
	RBF Paper	Oral Defense	Class Observation	Interview		RBF Paper	Oral Defense	Class Observation	Interview
A	Absent Absent Low	Low	High	High	E	Low Low High	Moderate	High	High
B	Low Low High	Low	Moderate	Moderate	F	Absent Low Moderate	Moderate	Moderate	High
C	Absent Moderate Moderate	Moderate	Absent	High	G	Low Moderate Moderate	Low	Moderate	High
D	Low Low Moderate	Low	Moderate	Moderate	H	Low Low Low	Low	High	High

* Italics denote a decrease in explicit understandings. Bold indicates an increase in explicit understandings.

The stronger links from content, materials and activities to student actions could be attributed to the student teaching experience. Generally, preservice teachers focus on the content, materials or activities needed to plan a lesson. Student teaching provides preservice teachers more experience specifically about these two elements of teaching and how they affect one another.

Teaching Behaviors and Strategies

Olson (2002) found the PBL group outperformed the non-PBL group when confronted with a parent who questions a teacher's use of questioning in the classroom. Consistent with her findings, the PBL group had slightly higher explicit articulations of effective teacher behaviors at the end of science methods class than the non-PBL group. As shown in Table 52, one non-PBL student's understandings decreased, while one PBL student's understandings increased from the RBF paper to the oral defense. The remaining students' understandings stayed the same.

Table 52. Summary of all participants' understandings of teacher behaviors and strategies.

Class A Non-PBL					Class B PBL				
	RBF Paper	Oral Defense	Class Observation	Interview		RBF Paper	Oral Defense	Class Observation	Interview
A	Low Low	Low	Moderate	Low	E	<i>Moderate High</i>	<i>Moderate</i>	<i>Moderate</i>	<i>Low</i>
B	Moderate Moderate	Low	Moderate	Moderate	F	<i>Low Low</i>	<i>Moderate</i>	<i>Low</i>	<i>Low</i>
C	<i>Low Moderate</i>	<i>Low</i>	<i>Absent</i>	<i>Absent</i>	G	Low Low	Low	Low	Moderate
D	Low Low	Low	Low	Low	H	Low Low	Low	Moderate	Low

* Italics denote a decrease in explicit understandings. Bold indicates an increase in explicit understandings.

While student teaching the PBL group expressed more teaching behaviors than the non-PBL group did. If non-PBL student teachers articulated teaching behaviors, they only mentioned questioning. However, if PBL student teachers articulated teaching behaviors, they mentioned questioning, wait time and nonverbals. In fact, one PBL student teacher articulated higher conceptions of teacher behaviors than those found in either her RBF paper or oral defense. The cause for one student's increase in explicit understandings of teacher behaviors is unknown. This could be attributable to many things, one of which could be the PBL tape. This same student mentioned how the PBL situation made her look at herself more closely and know how to evaluate herself and the lesson she planned.

Even though one student's conceptions of this element increased, the rest of the student teachers' understandings of this element of teaching stayed the same or slightly

decreased from science methods class. Three student teachers demonstrated better teacher behaviors than they could articulate, while one student teacher articulated teacher behaviors better than she could demonstrate them. The rest of the preservice teachers performed teacher behaviors that were equivalent to their explicit understandings during the student teaching interview.

Overall, the explicit understandings of this component of teaching are marginal, at best. Students say vague things like, “I need to be the facilitator,” but then fail to accurately describe what they really will be doing in the classroom. Emphasis was placed in the science methods class on specific teaching behaviors, such as effective questioning, responding to student comments with a question, using effective wait time I and II, and using nonverbals to promote desired student behavior. These behaviors work most effectively when used together; one alone is insufficient. Unfortunately, none of the preservice teachers in this study articulated more than three teacher behaviors, or had high connections between teacher behaviors and the student goals they had for their students. But at least the conceptions of this element of teaching, for 6 of 8 students, did not decrease from science methods to student teaching.

Learning Theory

During the science methods course, all students generally focused on the connections between content, materials and activities, and either constructivism, social or developmental learning theories. For the most part, no real differences can be distinguished between the PBL and non-PBL groups; developmental learning theory is the exception. During the oral defense, the non-PBL group had four low connections from content to developmental learning theory, while the PBL group had two low, one moderate and one high connection from content to developmental learning theory. This suggests that the PBL group made more connections, and better connections from content, materials or activities to developmental learning theory. Again, this is consistent with the Olson (2002) study because she found the “PBL group more readily mentioned how developmental levels of their students would influence what content they would teach” than the non-PBL group (p. 13).

Table 53. Summary of participants' understandings of learning theory and its connections to content, materials and activities.

Behavioral Learning Theory

Class A Non-PBL					Class B PBL				
	RBF Paper	Oral Defense	Class Observation	Interview		RBF Paper	Oral Defense	Class Observation	Interview
A	Absent	Absent	Moderate	Absent	E	Absent	Absent	Low	Absent
B	Absent	Absent	Low	Low	F	Absent	Absent	Low	Absent
C	<i>Low</i>	<i>Absent</i>	<i>High</i>	<i>Absent</i>	G	Low	Absent	Moderate	Low
D	Absent	Absent	Low	Absent	H	<i>Moderate</i>	<i>Absent</i>	<i>Moderate</i>	<i>Absent</i>

Constructivist Learning Theory

Class A Non-PBL					Class B PBL				
	RBF Paper	Oral Defense	Class Observation	Interview		RBF Paper	Oral Defense	Class Observation	Interview
A	<i>Low</i>	<i>Low</i>	<i>Moderate</i>	<i>Absent</i>	E	<i>High</i>	<i>Low</i>	<i>High</i>	<i>Absent</i>
B	<i>High</i>	<i>Low</i>	<i>Moderate</i>	<i>Absent</i>	F	<i>Low</i>	<i>Low</i>	<i>Moderate</i>	<i>Absent</i>
C	<i>Low</i>	<i>Low</i>	<i>Absent</i>	<i>Absent</i>	G	<i>Low</i>	<i>Low</i>	<i>Moderate</i>	<i>Absent</i>
D	<i>Moderate</i>	<i>Low</i>	<i>Moderate</i>	<i>Absent</i>	H	<i>Moderate</i>	<i>Absent</i>	<i>Moderate</i>	<i>Absent</i>

Social Learning Theory

Class A Non-PBL					Class B PBL				
	RBF Paper	Oral Defense	Class Observation	Interview		RBF Paper	Oral Defense	Class Observation	Interview
A	<i>Low</i>	<i>Low</i>	<i>Moderate</i>	<i>Absent</i>	E	<i>Absent</i>	<i>Low</i>	<i>High</i>	<i>Absent</i>
B	<i>High</i>	<i>Absent</i>	<i>Moderate</i>	<i>Low</i>	F	<i>Low</i>	<i>Low</i>	<i>Moderate</i>	<i>Absent</i>
C	<i>Low</i>	<i>Absent</i>	<i>Absent</i>	<i>Absent</i>	G	Absent	Absent	Moderate	Absent
D	<i>Absent</i>	<i>Low</i>	<i>Moderate</i>	<i>Absent</i>	H	<i>Absent</i>	<i>Low</i>	<i>Moderate</i>	<i>Absent</i>

Developmental Learning Theory

Class A Non-PBL					Class B PBL				
	RBF Paper	Oral Defense	Class Observation	Interview		RBF Paper	Oral Defense	Class Observation	Interview
A	<i>Absent</i>	<i>Low</i>	<i>Moderate</i>	<i>Absent</i>	E	<i>Moderate</i>	<i>High</i>	<i>High</i>	<i>Absent</i>
B	<i>Low</i>	<i>Low</i>	<i>Moderate</i>	<i>Absent</i>	F	<i>Low</i>	<i>Low</i>	<i>Moderate</i>	<i>Absent</i>
C	<i>Low</i>	<i>Low</i>	<i>Absent</i>	<i>Absent</i>	G	Low	Low	Absent	High
D	<i>Low</i>	<i>Low</i>	<i>Moderate</i>	<i>Absent</i>	H	<i>Moderate</i>	<i>Moderate</i>	<i>Moderate</i>	<i>Absent</i>

* Italics denote a decrease in explicit understandings. Bold indicates an increase in explicit understandings.

Table 54. Summary of participants' understandings of learning theory and its connections to teacher behaviors and strategies.

Behavioral Learning Theory

Class A Non-PBL					Class B PBL				
	RBF Paper	Oral Defense	Class Observation	Interview		RBF Paper	Oral Defense	Class Observation	Interview
A	Absent	Absent	Absent	Absent	E	<i>Absent</i>	<i>Low</i>	<i>Absent</i>	<i>Absent</i>
B	<i>Low</i>	<i>Absent</i>	<i>Moderate</i>	<i>Absent</i>	F	<i>Low</i>	<i>Absent</i>	<i>Moderate</i>	<i>Absent</i>
C	Absent	Absent	High	Absent	G	Absent	Absent	Moderate	Absent
D	<i>Low</i>	<i>Absent</i>	<i>Moderate</i>	<i>Absent</i>	H	Absent	Absent	Moderate	Absent

Constructivist Learning Theory

Class A Non-PBL					Class B PBL				
	RBF Paper	Oral Defense	Class Observation	Interview		RBF Paper	Oral Defense	Class Observation	Interview
A	<i>Low</i>	<i>Low</i>	<i>High</i>	<i>Absent</i>	E	<i>Moderate</i>	<i>Low</i>	<i>High</i>	<i>Absent</i>
B	<i>High</i>	<i>Low</i>	<i>Moderate</i>	<i>Absent</i>	F	<i>Low</i>	<i>Low</i>	<i>Low</i>	<i>Absent</i>
C	<i>Moderate</i>	<i>Low</i>	<i>Absent</i>	<i>Absent</i>	G	<i>Moderate</i>	<i>Low</i>	<i>Low</i>	<i>Absent</i>
D	<i>Moderate</i>	<i>Low</i>	<i>Moderate</i>	<i>Low</i>	H	<i>Low</i>	<i>Low</i>	<i>Moderate</i>	<i>Absent</i>

Social Learning Theory

Class A Non-PBL					Class B PBL				
	RBF Paper	Oral Defense	Class Observation	Interview		RBF Paper	Oral Defense	Class Observation	Interview
A	<i>Low</i>	<i>Absent</i>	<i>High</i>	<i>Absent</i>	E	<i>Low</i>	<i>Low</i>	<i>High</i>	<i>Absent</i>
B	<i>Moderate</i>	<i>Absent</i>	<i>Moderate</i>	<i>Absent</i>	F	<i>Low</i>	<i>Absent</i>	<i>Low</i>	<i>Absent</i>
C	<i>Low</i>	<i>Absent</i>	<i>Absent</i>	<i>Absent</i>	G	<i>Low</i>	<i>Absent</i>	<i>Low</i>	<i>Absent</i>
D	<i>Low</i>	<i>Absent</i>	<i>Moderate</i>	<i>Absent</i>	H	<i>Low</i>	<i>Absent</i>	<i>Moderate</i>	<i>Absent</i>

Developmental Learning Theory

Class A Non-PBL					Class B PBL				
	RBF Paper	Oral Defense	Class Observation	Interview		RBF Paper	Oral Defense	Class Observation	Interview
A	<i>Absent</i>	<i>Low</i>	<i>High</i>	<i>Absent</i>	E	<i>Absent</i>	<i>Low</i>	<i>High</i>	<i>Absent</i>
B	<i>Moderate</i>	<i>Absent</i>	<i>Moderate</i>	<i>Absent</i>	F	<i>Low</i>	<i>Low</i>	<i>Low</i>	<i>Absent</i>
C	Absent	Absent	Absent	Absent	G	<i>Absent</i>	<i>Low</i>	<i>Low</i>	<i>Absent</i>
D	Absent	Absent	Moderate	Absent	H	Absent	Absent	Moderate	Absent

* Italics denote a decrease in explicit understandings. Bold indicates an increase in explicit understandings.

In the RBF paper and oral defense, connections between learning theory and teacher behaviors and strategies generally were lower than those made between content, materials and activities. As shown in Tables 53 and 54, most connections were either absent or low in quality. Again, no distinguishable differences exist between the PBL group and the non-PBL group at the end of methods class in this area.

Regrettably, almost all explicit connections between learning theory and classroom decision-making were non-existent during the student teaching interview. This is sobering, but consistent with the findings of Skamp and Mueller (2001) who also found “references to research on how children learn ... virtually non-existent” in student teachers’ articulations (p. 242). In the non-PBL group, two very low articulations about behaviorism and social learning theory were made in reference to content, materials or activities, while one low statement was made about constructivism and its influence on teacher behaviors.

In the PBL group, only one articulation was made about developmental learning theory, but it was made a high level of understanding. The statement about developmental learning theory was made because this particular student teacher was wrestling with the issue of developmentally inappropriate content during her student teaching experience. This preservice teacher articulated a connection between the PBL tape’s developmentally inappropriate content and the dilemma she herself faced. This is encouraging because it appears that the specific problem students wrestled with and learned from during science methods carried over to affect the thinking for at least one student while she was student teaching.

Self-Evaluation

The PBL group noticeably articulated more thoughts about self-assessment than the non-PBL group. These findings are consistent with the Olson (2002) study. She found PBL students were more likely to articulate the need for self-assessment in the classroom than those students who did not have the PBL experience. As shown in Table 55, while student teaching none of the non-PBL students articulated thoughts about self-assessment. In stark contrast, one PBL student teacher videotaped herself during the observed lesson and later

mentioned how she had done so previously and was working on her nonverbal behavior. Another PBL student also articulated the importance of self-evaluation.

Table 55. Summary of participants' understandings of self-evaluation.

Class A Non-PBL					Class B PBL				
	RBF Paper	Oral Defense	Class Observation	Interview		RBF Paper	Oral Defense	Class Observation	Interview
A	<i>Moderate</i>	<i>Low</i>	<i>N/A</i>	<i>Absent</i>	E	Absent	Low	Low	Low
B	<i>Moderate</i>	<i>Low</i>	<i>N/A</i>	<i>Absent</i>	F	<i>High</i>	<i>Low</i>	<i>N/A</i>	<i>Absent</i>
C	<i>High</i>	<i>Low</i>	<i>N/A</i>	<i>Absent</i>	G	Moderate	Low	N/A	Moderate
D	<i>High</i>	<i>Low</i>	<i>N/A</i>	<i>Absent</i>	H	<i>Absent</i>	<i>Low</i>	<i>N/A</i>	<i>Absent</i>

* Italics denote a decrease in explicit understandings. Bold indicates an increase in explicit understandings.

Overall, these differences are attributable to the PBL tape. Students in both groups had the experience of audiotaping themselves and coding their questioning and responding patterns during their methods practicum. However, only the PBL group had the experience of overtly analyzing another teacher's lesson using the components of effective teaching found in Appendix A. This lesson analysis seems to have made the need for self-assessment more relevant and important for the PBL preservice teachers.

Implications

The Importance of the Problem

Overall, the higher articulations made by the PBL group were consistent with the discrepancies evident in the PBL scenario, which suggests that PBL embedded within a RBF classroom has positive effects on preservice teachers' conceptions of teaching and learning. The problem solved during science methods focused students' attention on developmentally inappropriate science content, ineffective teacher behaviors, and the discrepancies between what the teacher's explicit goals were for the lesson and what she actually demonstrated. Through the completion of this assignment, it appears as though higher conceptions of developmental learning theory and its influence on content, teacher behaviors, goals and self-evaluation carried over into the preservice teachers student teaching experience.

This suggests how important problem selection is to problem-based learning. Interesting questions that arise from this are: What happens if a different PBL scenario is used? Will students continue to learn only in the areas the tape is discrepant? What if the entire lesson is discrepant? Will students only focus on two or three big ideas and forget the remaining discrepancies? Further research is needed on PBL and its use in elementary science methods classrooms, specifically in the context of an RBF methods classroom.

The Complexities of Teaching

This study demonstrates how difficult it is to prepare effective elementary science teachers; this is consistent with research conducted by Luft, Bragg, and Peters (1999). It is sobering to see students' explicit articulations dwindle during student teaching, especially considering their explicit understandings were not exceptional to begin with. Generally, the implicit and demonstrated understandings were higher than what was articulated while student teaching. Having an explicit knowledge base is crucial for deliberately improving teaching practices (Clough & Kauffman, 1999), and in presenting oneself as a competent professional (Fullan, 1996). Unfortunately, because the student teachers could not adequately articulate several components of their research-based framework for science while student teaching, these preservice teachers may face difficulties when trying to improve their own practices, and when facing a skeptical public.

Imperative for student teachers' success in the classroom and continual use of their RBF is to be placed with a cooperating teacher who understands the RBF process and has consciously competent understandings of the components of effective instruction found in Appendix A. Research indicates that cooperating teachers are key factors for student teachers' continual conceptual change (Gunstone & Northfield, 1992; in Skamp & Mueller, 2001). Unfortunately, few elementary teachers have such explicit knowledge. The student teachers' explicit knowledge base in this study may have dwindled from those expressed during science methods because the cooperating teachers did not provide the dialogue, experience or expertise needed to promote continual and explicit change in their student teachers. Further research to examine the knowledge base of the cooperating teacher and its impact on the student teacher are needed. Specifically, research comparing cooperating

teachers who have undergone an RBF experience versus those who have not is needed to see what impact an RBF has on the process.

Given the marginal explicit understandings and low to moderate implicit demonstrations while student teaching, one science methods course may be inadequate for effectively preparing elementary science teachers. All preservice teachers in this study participated in one semester long science methods course. Numedahl and Clough (2001) observed that students' RBF papers and oral defense responses were more robust after having a second science methods course structured around the RBF. It could be argued that these preservice elementary teachers also took other subject methods courses, but science methods was the only course in the teacher education program to focus explicitly on the elements of effective teaching found in Appendix A, and how those elements inform each other. Good teaching is not dependent upon subject matter; therefore expanding the use of the RBF into other elementary subject areas may prove beneficial in preparing effective elementary teachers.

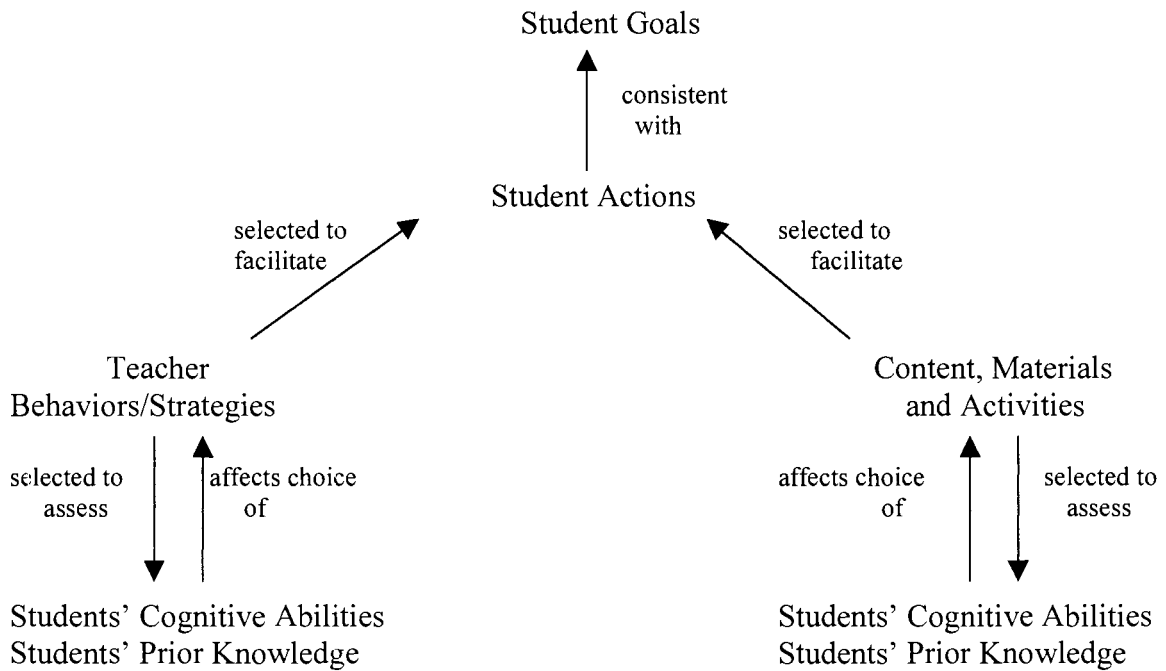
Student teachers face many constraints and the common excuse heard during interviews and observations was, "I would do it differently if I had my own room." In order to determine if student teachers would truly do things differently if given the chance, longitudinal studies need to be done comparing to determine the long-term effects of PBL embedded within a research-based framework context. Specifically, comparing the articulations of students during science methods, the demonstrations and articulations of student teaching and consequently the demonstrations and articulations of their first few years of teaching are needed to adequately determine the full effects a science methods course can have on teachers' understanding and practices. Another reason longitudinal studies would be helpful is student teachers are novices at their profession. One would expect them to not have all aspects of teaching and learning pieced together as succinctly as a more experienced and educated teacher. It may very well be that new teachers need a few years to fully understand the elements of effective instruction used in the RBF schematic at the level needed to use them explicitly to inform their professional practice.

After completing this study, the researcher noted several improvements that could have been made. First, one observation is not sufficient to convey an accurate picture of a

person's tacit understandings. To get a clearer understanding of how well preservice teachers perform in the classroom, multiple classroom visits should be arranged in further studies. Second, more time should be spent with the student teacher during the interview and more extensive probing should occur to get a deeper sense of the explicit understandings that remain. Third, further research should include the cooperating teacher in an interview to get a sense of how closely the student teachers' and cooperating teachers' epistemologies and beliefs match. A mismatch here could drastically affect the learning that occurs during student teaching. Even though these suggestions would have added more depth to the study, as is, this study describes the understandings of eight preservice teachers and how those understandings changed over time, in great depth, and helps us better understand what components of the RBF transfer to the student teaching experience.

The purpose of this study was to determine the effects PBL had on preservice teachers' conceptions of teaching and learning at the end of a science methods course and while student teaching. Further research is needed to determine the full effect of PBL when used within an RBF science methods course for elementary teachers. Overall, the findings of this qualitative study suggest the PBL scenario did affect the students' conceptions of teaching and learning in a positive manner, particularly in areas that were problematic on the PBL tape.

Appendix A. Components of a Research-Based Framework for Teaching Science



From Clough & Kauffman, 1999, p. 2.

Appendix B. Unit Plan Guidelines for Spring 2001

As stated in the syllabus, you will be developing (with a colleague) a set of five consecutive science lesson plans for a grade level you plan to teach. Your unit plan should have the following components:

1. Your **goals** for your students. Remember, these are your big goals. They are more broad than objectives. For example, one of my goals is for students to creatively solve problems. This is much broader than an objective that students will design a test to determine how much light an earthworm prefers. You may have 10-12 overall goals for students for the school year. These should be listed, but then tell me which of them your unit will address. You may only address 1 or 2 of your big goals in the unit. That's fine.
2. A **concept map** of the content/processes that you will be addressing in the unit, showing how all the pieces fit together.
3. **What do kids know about the topic?** (Find two or three kids and ask them what they know about your topic. This will give you a good idea of where to start!) Also, make sure that your lessons are sensitive to the things they said! If they have a misconception, make sure your lessons are going to address it somewhere; don't ignore their prior knowledge!
4. **Lesson plans:** -A minimum of five, even though this may take more than five days. Remember, some lessons can span several class sessions.
 - a. Begin each lesson with the **goal** that will be addressed, followed by your **student actions and learning objectives**.
 - b. **Materials** you'll need
 - c. **Instructional sequence** (for traditional instruction, this would include the anticipatory set, etc., learning Cycle would begin with Exploration, Group Investigation may begin with a motivating activity followed by group development of research questions, etc.) The structure you choose is up to you. Use your professional judgment, but choose a structure that makes sense. For example, I wouldn't use conceptual change instruction with a topic kids know nothing about. There aren't major concepts to change in this case!
 - d. **Assessment**—part of the instructional sequence! If you use a formative assessment, it will appear within the lessons throughout the unit somewhere. Summative assessment will be near the end, and counts as one of the five lessons, even though the structure may be dramatically different than a regular lesson plan.
5. Your **rationale** for your lessons. Describe why you chose the structures you did for your lessons, and why you decided to do the learning experiences you chose. Also describe your assessment, why you placed it where you did, and why you feel it is an appropriate assessment for your goals and objectives.

Handy Helpful Hints For your lessons:

- Write out the questions that will be on your assessment. (If they're writing in journals, what's the topic? If you are using a checklist, write out what you're assessing them on!)
- Ask yourself: Who is doing the thinking? Put the thinking on the kids!
- Don't expect kids to "discover" most science concepts on their own. That's where you come in!
- Choose the right tool for the right job. Don't try to force lessons into models where they won't work.
- Find activity books, then use those activities and "decookbook" them. You don't have to reinvent the wheel!
- Don't forget your role! **This isn't a list of what the kids do, but a description of what will happen in the classroom.** If you have a class discussion planned, what questions will you pose to get it started? Will they be in a circle? In groups? Sharing results on chart paper? Compiling a class list? Putting findings on the board? How will you keep the discussion going? What key ideas will you try to get the kids to elucidate? How will you get them there?
- Cite sources if you use them.
- Print it out and staple it. Please don't spend your valuable time adding binding, colored paper, etc.

Appendix C. PBL Guidelines for Fall 2001

Context of this teaching scenario:

Mrs. S. teaches third grade in a small rural school in Iowa. Her class has completed about 2/3 of a unit on physical and chemical changes. She calls this lesson a “show what you know” lesson. “My objective is to have students show what they’ve learned so far and to involve them in observing evidence of chemical change.”

Your challenge is to evaluate this teaching scenario, and to develop your own lessons for this objective using your own goals for your students.

As a group, evaluate this lesson using the schematic given in the syllabus. As stated in class, you have a lot of the pieces, but now it’s time to make the connections between them! Your analysis should be thorough, well-articulated, well-reasoned, and based on evidence provided in the videotape. Feel free to support your judgments with literature provided in class or items you find on your own. Cite sources.

As an individual, you will turn in your own rewrite of this lesson along with a lesson that would follow this one. (2 lesson plans total) Your lessons should also demonstrate that you are making connections between the items on the schematic. Your lessons should include the following components:

1. A **concept map** illustrating what big ideas you’re trying to teach, supporting ideas, and how they’re connected together.
2. **What do kids know about the topic?** This information can be determined from the videotape, or find some children of comparable age and ask them! This will give you a good idea of where to start! Also, make sure that your lessons are sensitive to the things they said. If they have a misconception, make sure your lessons are going to address it somewhere; don’t ignore their prior knowledge!
3. **Lesson plans:**
 - a. **Goals** that will be addressed in the lesson
 - b. **Student actions** and **learning objectives**
 - c. **Materials** you’ll need
 - d. **Instructional sequence** (for traditional instruction, this would include the anticipatory set, etc., learning Cycle would begin with Exploration, Group Investigation may begin with a motivating activity followed by group development of research questions, etc.) The structure you choose is up to you. Use your professional judgment, but choose a structure that makes sense. For example, I wouldn’t use conceptual change instruction with a topic kids know nothing about. There aren’t major concepts to change in this case!
 - e. **Assessment**—part of the instructional sequence! If you use a formative assessment, it will appear within the lessons throughout the unit somewhere. Summative assessment will be near the end.
4. Your **rationale** for your lessons. Describe why you chose the structures you did for your lessons, and why you decided to do the learning experiences you chose. Also describe your assessment, why you placed it where you did, and why you feel it is an appropriate assessment for your goals and objectives.

Handy helpful hints:

For your group analysis task:

1. Clarify unknown terms and concepts in the scenario description.
2. Define the problem; that is, list the components of the scenario to be explained.
3. Analyze the problem; “brainstorm;” try to produce as many different explanations for the scenario as you can. Use prior knowledge and common sense.
4. Criticize the explanations proposed and try to produce a coherent description of the processes that, according to what you think, underlie the scenario.
5. Formulate learning issues that you have.
6. Fill in the gaps in your knowledge through self-study.
7. Share your findings with your group and try to integrate the knowledge acquired into a comprehensive explanation for the scenario. Check whether you know enough now.*

8. Go back to the schematic and determine how all the pieces fit together.

I also recommend that you view this tape several times. This task is more than dividing the work among group members. You will need each other's knowledge to fully address the complexities of this classroom scenario. Push each other conceptually, and see me if you are getting stuck or need additional assistance or support.

For your lessons:

- Write out the questions that will be on your assessment. (If they're writing in journals, what's the topic? If you are using a checklist, write out what you're assessing them on!)
- Ask yourself: Who is doing the thinking? Put the thinking on the kids!
- Don't expect kids to "discover" most science concepts on their own. That's where you come in!
- Choose the right tool for the right job. Don't try to force lessons into models where they won't work.
- Find activity books, then use those activities and "decookbook" them. You don't have to reinvent the wheel!
- Don't forget your role! This isn't a list of what the kids do, but a description of what will happen in the classroom. If you have a class discussion planned, what questions will you pose to get it started? Will they be in a circle? In groups? Sharing results on chart paper? Compiling a class list? Putting findings on the board? How will you keep the discussion going? What key ideas will you try to get the kids to elucidate? How will you get them there?
- Cite sources if you use them.
- Print it out and staple it. Please don't spend your valuable time adding binding, colored paper, etc.

*This list was modified from Schmidt, H.G., & Moust, J.H.C. (2000). Factors affecting small group tutorial learning: A review of research. In *Problem-Based Learning. A research perspective on learning interactions*. Evensen, D.H. & Hmelo, C.E. (Eds.). Lawrence Erlbaum Associates: New Jersey.

Appendix D. Grade Definitions for CI 449

As stated in the syllabus, students in CI 449 are expected to thoroughly complete all assignments, attend all classes, and extensively participate in class. Missing class is as serious as missing a day as a teacher. At the end of the course, you will be asked to state and justify a final grade using the following grade definitions. Your final grade for the course will be determined by your performance compared to the grade definitions, how accurately you assess your teaching and needed growth, and your professionalism. All criteria under a particular grade definition must be met to defend that grade. Minor discrepancies allow for a minus. Exceeding the grade definitions allow for a plus.

A This individual is extremely well-qualified as evidenced by 1) clearly stated student goals informed by research, 2) a thorough research-based framework for teaching science (both written and oral) that indicates a robust understanding of learning and teaching, and 3) extensive and accurate self evaluation showing an understanding of the desired state, discrepancies, and recommendations to move progressively toward the desired state. All assignments are thorough, show great effort and are turned in on time. This person demonstrates excellent and thorough lesson planning, a strong command of subject matter, and discusses issues and research in science education. All of these have been well demonstrated through active participation in class sessions. This person never gives the impression of learning simply by listening. This person uses research findings to support statements and exhibits a passion for teaching. This person has an exemplary attendance rate, almost never arrives late or leaves early, and demonstrates a positive, friendly and professional attitude. Few students typically earn an “A” in this course.

B This individual is well-qualified as evidenced by 1) student goals informed by research, 2) a research-based framework for teaching science (written and oral) that indicates an understanding of learning and teaching, and 3) self evaluation showing an understanding of the desired state, discrepancies, and recommendations to move progressively toward the desired state. All assignments are thorough, show very good effort and are turned in on time. This person demonstrates very good lesson planning, a good grasp of the subject matter, good student rapport and discusses issues and research in science education. All of these have been demonstrated through active participation in class sessions. This person rarely gives the impression of learning simply by listening. This person uses research findings to support most statements but misses other appropriate opportunities. A strong commitment to teaching is always exhibited. This person misses two or fewer classes, sometimes arrives late or leaves early, and demonstrates a positive, cordial and professional attitude. The “B” student, with effort, shows every sign of becoming an “A” teacher.

C This individual shows the basic competencies necessary for elementary science teaching. This student may be quite successful in some areas and not so successful in others. Special attention during student teaching will likely be required to ensure effective teaching that matches the desired state. The C student has goals for students, but has difficulty making clear the connections between student goals, student actions, teacher behaviors/strategies, content, materials, and activities, and education research. All assignments are turned in, but they sometimes are skeletal or late. This person misses class more than 3 times, and often arrives late or leaves early. This person has a sufficient grasp of subject matter, demonstrates satisfactory lesson planning and student rapport, but is sometimes cynical toward education research. This individual demonstrates a satisfactory commitment to teaching, but does not make important connections that are required for exemplary science teaching.

Rubric For Science Methods	Formal Operational Teacher Grade = A	Transitional Between Concrete and Formal Operational Teacher Grade = B	Concrete Operational Teacher Grade = C
Contributions To Class Discussions	Constructive comments contributed each class without hindering other students from speaking. positive influence on discussion.	Constructive comments contributed sporadically. Does not hinder other students & creates a positive atmosphere for discussion.	Mostly contributes when called upon. Sometimes takes discussion off task and contributions are sometimes not positive.
Attendance	Misses class only in a true emergency. Does not arrive late or leave early.	Misses 2 or less classes. Almost never arrives late or leaves early.	For any reason misses 3 or more classes. Sometimes arrives late or leaves early.
Attitude	Very positive attitude & always enthusiastic about teaching. Demonstrates a sense of humor and is always professional.	Positive attitude, cordial, and usually enthusiastic about teaching. Most always professional.	No general attitude may be discernable. May exhibit cynicism, complaining, or anger. Often professional.
Work-Ethic	Always prepared for class. Constantly working in class. Takes on unassigned tasks. Most always vigorous & altruistic.	Not always prepared for class. Not always working in class. Rarely takes on unassigned tasks. Usually vigorous and altruistic.	Often not prepared for class and/or unproductive. Simply does what is assigned. Rarely vigorous & altruistic.
Goals	Always remembers goals and frequently refers to their interactions.	Has goals but does not always refer to them and their interactions.	Has goals but often ignores them. Rarely addresses interactions.
Self-Reflection And Open to Criticism	Always accurately critiques self and seeks others critique to improve. Not defensive!	Usually accurately critiques self. Usually seeks others critique. Rarely defensive.	Sometimes accurately critiques self. Sometimes seeks others critique. Sometimes defensive.
Research Based Framework for Teaching Science	All student goals reflect the consensus reached in the sci. ed. community. Each goal is taken through the schematic using extensive & specific research-based strategies. Reflection is extensive. *	Student goals reflect the consensus reached in the sci. ed. community. Has trouble at times taking goals through the schematic and applying research. Research and reflection are lacking in some areas.	Some student goals reflect the consensus reached in the sci. ed. community. Has difficulty taking goals through the schematic. Important research support is missing. Little attention to class & relevant topics.
Exit Interview	Clearly articulates the important aspects of a RBF for teaching science. Shows understanding of complex interactions. Responses and examples are relevant & to the point.	Omits a few important aspects of a RBF for teaching science. Understanding of complex interactions is unclear. Responses and examples are sometimes vague & not to the point.	Omits critical aspects of a RBF. Understanding of complex interactions not often evident. Responses and examples are often vague, not to the point, & portrays shotgun approach.

*Cites many specific examples demonstrating a clear picture of the desired state of science teaching and what YOU will do in the classroom to make this a reality. RBF should reflect contemporary learning theory questioning, wait time, responding behaviors, learning cycle, cooperative learning, highly interactive teaching, assessment, etc. Citations demonstrate additional student research.

Appendix E. Coding Guide For RBF Paper

(Modified from Clough, Numedahl, and Olson, 2001)

Student Actions linked to Student Goals

Absent: Not addressed.

Low: A vague sentence or two stating that the goals interact and feed off each other.

Exemplar: “Teachers need to be aware of that [sic] everything they do in the classroom is intertwined. Although all of the goals I have set for my classroom intermix, I have separated them to explain each individually.”

Moderate: Statement is made regarding the interaction of some student goals, but misses several other opportunities.

Exemplar: “Students will be active in the classroom by doing group work, which will require participation of all students (as discussed earlier) and contributing their ideas.” “Collaborative learning...started early, this will also help students themselves become better communicators, develop better social skills, and have a conceptual understanding of the content. (connections!!!)”

High: Numerous interactions of student goals are explicitly stated.

Exemplar: Similar to Moderate, but misses few connections.

Teacher Behaviors and Strategies linked to Student Actions

Absent: Teaching behaviors and strategies are not addressed.

	Quality	Frequency
LOW	Low: States Behavior or Strategy	Low: addressed in 1-3 goals
	Low	Moderate: addressed in 4-6 goals
	Low	High: addressed in 7+ goals
MODERATE	Moderate: States Behavior or Strategy and vaguely connects it to goals.	Low
	Moderate	Moderate
	Moderate	High
HIGH	High: Explains Behavior or Strategy and accurately connects it to goals.	Low
	High	Moderate
	High	High

Teaching Strategies

Low Quality Exemplar: “My role as a teacher is, first of all, to set a good example.”

Moderate Quality Exemplar: “I need to be an effective communicator myself so that the students who learn through the social learning theory can have a model.”

High Quality Exemplar: “I need to be encouraging students to be actively involved in the classroom and other activities, by talking, taking notes, or being an active listener, so that they get a feeling of importance and realize they can make a difference.”

Teaching Behaviors

Low Quality Exemplar: “I need to make sure I am always attending to what the students are saying and paying attention to how I respond and what I look like while listening.”

Moderate Quality Exemplar: “My role in helping to develop self worth is to ask questions so that students provide reasoning for their answers, and therefore are confident with their opinions.”

High Quality Exemplar:

Selection of Content, Materials and Activities linked to Student Actions

Each one of these is considered separately.

Absent: Selection of Content, Materials, or Activities is not addressed.

Low: No explicit statements regarding the link to student goals. Link, at best, is implicit.

Exemplars: “They could chart data using their own ideas of how to sort it, then explain their reasoning to the class.” OR “Activities should include things such as writing, investigating, researching, experimenting, questioning, and etc.”

Moderate: A general statement is made regarding the link to student goals. This statement may be vague or circular in nature.

Exemplar: “Newspapers can supply problem-solving opportunities with connections to science and other interdisciplinary areas.”

High: Makes a general statement, but explains the characteristics of activities, materials, or content that will be most appropriate for facilitating a goal or goals.

Exemplar: “The teacher will provide the students with hands-on problem-solving activities so that they will learn together by communicating, sharing ideas and materials, taking on responsibilities, listening to each other and completing the assigned task.”

Learning Theories Linked to Teacher Behaviors and Strategies

Each learning theory will be considered separately.

Absent: The learning theory is not addressed at all with reference to teaching behaviors and/or strategies.

Low: The link from teaching behaviors/strategies to learning theory is addressed, but is inaccurate.

Exemplars: “I will use the social learning theory to model to my students the joy that being a life-long learner can bring to one’s life.” OR “The constructivist theory is based on students’ prior knowledge. I must find this out before I can decide how much academic responsibility my students can handle independently.” OR “The behavioral learning theory comes into play as I observe the behaviors of my students.”

Moderate: The link from teaching behaviors/strategies to learning theory is vague, or definitional.

Exemplars: “The social learning theory is in action here with teachers constantly modeling and children following examples.”

High: The link from teaching behaviors/strategies to learning theory is accurate.

Exemplar: “In order to foster higher-order thinking in students, teachers must ask deliberate questions and use deliberate actions. When asking questions it is important to ask opinion, perception, application, or experience questions rather than fact or accepted standard questions. These types of questions get to the core of the students’ knowledge and reveal to the teacher if there are any misconceptions related to the concept. When an answer is given, the teacher should ask for elaboration

or clarification from the student when necessary. This puts the thinking back on the students and allows them to explain or justify their solutions or opinions.”

Learning Theory linked to Content, Materials and Activities

Each learning theory will be considered separately.

Absent: The learning theory is not addressed at all with reference to teaching behaviors and/or strategies.

Low: The link from content, materials or activities to learning theory is addressed, but is inaccurate.

Exemplar: “Instructors must be aware of the different stages students are at and work to design activities that appeal to students at all developmental levels.”

Moderate: The link from content, materials or activities to learning theory is vague, or definitional.

Exemplars: “The teacher need to developmentally know what level his students are at so he can offer developmentally appropriate activities.” OR “It is very important for the teacher to choose activities based on the student’s prior knowledge.”

High: The link from content, materials, or activities to learning theory is accurate.

Exemplar: The ability to develop problem-solving and decision-making skills also rests in the developmental theory because the developmental level of the student directly relates to his/her ability to solve problems. Students at the formal level are able to come up with more abstract ways of solving a problem while students at the concrete level are limited to what they can see.”

How Will Student Judge Whether they are a Successful Teacher?

Absent: Assessment not addressed.

Low: This prospective teacher neglects the variety of school settings and uninformed colleagues and administrators. Any student, colleague or administrator will assess them.

Exemplar:

Moderate: Statement reflects informed practice as it acknowledges the importance of being personally aware of the actual and desired state. The focus is on self-analysis.

Exemplar: “I will assess my teaching by continuing to audiotape and videotape my teaching at least once a month. This will keep me consciously aware of my teaching habits and where I need to improve. I will listen and watch these tapes and jot down areas in which I need to improve.”

High: Statement reflects that all of the following are needed for an informed judgment: self-analysis, student performance, feedback from knowledgeable Colleagues and Administrators.

Exemplar: “To perform self-assessment on my teaching skills, I will periodically record myself teaching so that I can determine the kinds of questions I pose to my students, how much wait time I give, and how will I use non-verbal communication. I will ask colleagues that I respect as highly effective instructors to watch the recordings of my teaching and provide me with suggestions and feedback. I will also ask for feedback from my students to let me know how they think I am doing and to hear about any changes they would like to take place in our classroom.”

Appendix F. Questions From Oral Defense

1. How will you promote the goal of _____?
2. What is the value of having multiple strategies to reach your goal?
3. How would you decide what _____ (content, materials, or activities) to teach?
- 4a. How would you respond if a parent came into your classroom complaining about cooperative groups?

Or

- 4b. How would you respond if a parent wants to know why every time their child asks a question, you respond by asking them another question.
5. How will you know if you are an effective teacher?

Appendix G. Coding Guide for Oral Defense

From Olson, 2002.

Question One: How will you facilitate the goal of _____ in your classroom? (Links between goals, students actions, teacher behaviors/strategies, and content, materials & activities)

Count the number of probing questions required after the original questions before students mention:

- A. Questioning
- B. Wait Time
- C. Responding
- D. Nonverbals

<u>Code for Qualitative Study</u>	<u>Code from Olson (2002)</u>	<u># of Probes</u>
High	1	0
Moderate	2	1-2
Moderate	3	3-4
Low	4	5-7
Low	5	8+

Question Two: What is the value of having multiple strategies to promote this goal? (Links between learning theory and teacher strategies, as well as links between goals)

<u>Code for Qualitative Study</u>	<u>Code from Olson (2002)</u>
Low	Ia. Less boring (for students or the teacher)
Low	Ib. If one strategy doesn't work, you have something else to try
Moderate	II. Students learn differently, so what works for one may not work for others
High	IIIa. You can reach multiple goals simultaneously
High	IIIb. Strategies often have to work together to be effective

Question Three: How will you decide what (content to teach, activities to use with, or materials to use with) your students? (Links between learning theory and content/materials/activities, content/materials/activities and goals)

Includes the response in its entirety (including responses to probing questions).

1. The students' understanding of the influence of learning theory on content/materials/activities:

<u>Code for Qualitative Study</u>	<u>Code from Olson (2002)</u>
Low	Ia. (trial and error) Exemplar: I'll pick a (topic, activity, piece of equipment) and I'll see what works.
Low	Ib. (weak understanding of learning theory) Exemplars: Because students are in different stages, that will be important. OR I'll use hands-on materials because students have to construct their own understandings.
Moderate	IIa. (definitional—student says the words, then tries to apply it) Exemplars: Developmental learning theory says that students have developmental stages, so I'll need to consider their stage when I teach. OR Constructivist learning theory says that students build on their prior knowledge, so I'll pick topics that they have some prior knowledge about. OR Social learning theory says that students learn through social interactions, so I'll use activities that

require them to work together.

Moderate IIb. (uses learning theory without reciting a definition)
Exemplars: I'll need to make sure the content is developmentally appropriate. OR I'll use materials that aren't too abstract for my students to understand, especially if they are concrete operational.

High IIIa. (uses more than one learning theory without reciting definitions)

Exemplar: (see IIb. Above, but will include more than one response)

High IIIb. (Links learning theories, goals, and content/materials/activities)

Exemplars: If I want students to be critical thinkers and problem solvers, I'll choose activities that require them to solve novel problems. These activities will have to be appropriate for the students' developmental levels, while challenging their thinking and helping them to construct new understandings about the science concept.

- Record the number of probing questions required to get the student to address the influence of learning theory.

<u>Code for Qualitative Study</u>	<u>Code from Olson (2002)</u>	<u># of Probes</u>
High	1	0
Moderate	2	1-2
Moderate	3	3-4
Low	4	5-7
Low	5	8+

Question Four: How will you respond if a parent complains that when his daughter asks you questions in class, you respond to her questions with a question? (link between teacher behaviors and learning theory, and teacher behaviors and goals)

Read only their first response to this question. Students may provide multiple responses; record all responses they provide before any probing questions were asked.

<u>Code for Qualitative Study</u>	<u>Code from Olson (2002)</u>
Low	I. (student focus, rule based): Its' good for the student to struggle.
Moderate	IIa. (student focus): Questions promote deeper thinking.
Moderate	IIb. (teacher focus): Questions help me know how the student thinks.
Moderate	IIc. (teacher focus, link to learning theory): Because students may develop misconceptions, I have to know how the student is thinking.
High	IIIa. (goal focus): Questioning promotes my goal of critical thinking.
High	IIIb. (teacher and student focus): I have to promote deeper thinking among my students, while at the same time monitoring how they are making sense of the information. (a combination of diagnosis and deeper thinking)

Question Five: How will you respond if a parent questions your rationale for using cooperative groups? (links between learning theory and activities/strategies, activities/strategies and goals)

Read only their first response to the question. Students may provide multiple responses to this question. Record all responses they provide before any probing questions were asked.

<u>Code for Qualitative Study</u>	<u>Code from Olson (2002)</u>
Low	Ia. Cave in to Parent Exemplars: We're not using cooperative groups all the time. OR I would ask the parent how I should do it better.
Low	Ib. Explanation based on rules

Exemplars: Cooperative learning is a good thing. OR Students need to teach each other things. OR The real world requires people to work together.

Moderate IIa. Misuse of Learning Theory

Exemplars: Students have to construct, so they should work together. OR Students have to discover content for themselves, so they should teach each other.

Moderate IIb. Definitional use of Learning Theory

Exemplar: Social learning theory says that students learn from others, so I'll have them work with others.

High IIIa. Uses learning theory without citing a definition

Exemplar: Students learn better when they can interact with each other and hear how others think.

High IIIb. Link to other goals

Exemplar: I want more than just content understanding in my classroom. I also want students to be productive citizens and effective communicators. This requires them to develop these skills and one way to accomplish this is through the use of cooperative groups.

Appendix H. Coding Guide for Classroom Observations

Student Actions linked to Student Goals

Absent: Student actions demonstrate that the only goal observable is that of content.

Low: Student actions demonstrate that one or two goals, other than content, from the student teacher's RBF paper are observable.

Moderate: Student actions demonstrate that three or four goals, other than content, from the student teacher's RBF paper are observable.

High: Student actions demonstrate that five or more goals, other than content, from the student teacher's RBF paper are observable.

Teaching Behaviors and Strategies linked to Student Actions

Absent: No evidence of teaching behaviors or strategies that would promote student goals found in the student teacher's RBF paper are observable. Teaching behaviors and strategies are centered on classroom management, not learning.

Low: Teacher shows sporadic evidence of using one or two teaching behaviors or strategies that may promote some student goals found in the RBF paper. The teaching behaviors are not used as a package and may not be very efficient in reaching goals or student actions. (i.e. Teacher asks good questions occasionally, but fails to use effective wait time or student-centered responding patterns.)

Moderate: Teacher shows evidence of using two or more teaching behaviors or strategies in a fairly frequent and effective manner, but misses some opportunities to use them as an effective package to reach many of the student goals listed in the RBF paper. (ie. Teacher asks good questions and uses wait time frequently in the interactions with the class.)

High: Teacher demonstrates effective use of the package of teaching behaviors and strategies such as high level questioning, wait time I and II, student-centered responding patterns, and non-verbals. This teacher almost always uses teaching behaviors and strategies to directly attain student actions and goals found in the RBF paper.

Content, Materials and Activities linked to Student Actions

Absent: Content, materials and activities observed elicit student actions to attain the goal of content. The content, materials and activities failed to elicit student actions that would attain other goals stated in the RBF paper.

Low: Content, materials and activities observed elicit student actions that would attain one or two goals, other than content, stated in the RBF paper.

Moderate: Content, materials and activities observed elicit student actions that would attain three or four goals, other than content, stated in the RBF paper.

High: Content, materials and activities observed elicit student actions that would attain five or more goals, other than content, stated in the RBF paper.

Learning Theory linked to Teaching Behaviors and Strategies

Constructivism, Social and Developmental Learning Theories are clumped together into one group. This leaves Behaviorism as the other option.

Absent: Teaching behaviors and strategies observed fail to reflect the learning theory.

Low: Teaching behaviors and strategies observed reflect the learning theory but are used sparingly and/or ineffectively a majority of the time.

Moderate: Teaching behaviors and strategies observed reflect the learning theory and are used somewhat effectively about half the time.

High: Teaching behaviors and strategies observed reflect the learning theory and are used effectively much of the time.

Learning Theory linked to Content, Materials and Activities

Constructivism, Social and Developmental Learning Theories are clumped together into one group. This leaves Behaviorism as the other option.

Absent: The content, materials and activities observed do not reflect the learning theory. (i.e. The content is developmentally inappropriate.)

Low: The content, materials and activities observed minimally reflect the learning theory. (i.e. Students are physically seated in groups, but are not interacting with one another. A KWL chart is completed but not referred to again within the unit.)

Moderate: The content, materials and activities observed moderately reflect the learning theory. (i.e. Students are given a chance to explore and discuss the way cups roll down ramps, but the science content of balance and motion is not explicitly addressed. Students are left to consolidate content ideas on their own.)

High: The content, materials and activities observed fully reflect the particular learning theory. (i.e. Students fill out worksheets individually, and answer the teacher's short answer questions with the correct response. Those who get their work done on time receive a bonus point.)

Appendix I. Interview Questions

1. What would you say are your goals for your students when it comes to their learning of science?
2. What evidence do you have the students meet your goals?
3. What do you feel is your role in helping your students meet these goals?
4. How comfortable are you at this point in teaching elementary science?
5. What have you found to be easiest for you with regards to teaching elementary science?
6. What have you found to be the most difficult for you with regards to teaching elementary science?
7. How has the RBF influenced your teaching? In what subtle or overt ways have you used the ideas from your RBF?
8. How closely did what you write in your RBF and defend in the oral defense match what you have experienced so far in student teaching? Can you give any example?
9. What would you suggest to make the RBF and its oral defense more meaningful for pre-service teachers?
10. How well do you feel your science methods class prepared you for teaching?
11. What recommendations do you have for methods instructors at ISU?

Appendix J. Coding Guide for Interview Responses

Student Actions linked to Student Goals

Absent: Statement refers only to the goal of content.

Exemplar—“The same goal that the district uses, just experiencing it and getting the feel for it.”

Low: Statement refers to one or two goals besides content.

Exemplar—“I want them to get the big concepts. My goal [is] is have them talk it out and figure it out. I want them to think about it.”

Moderate: Statement refers to several goals but fails to mention interactions between goals.

Exemplar—“My goals were basically for them to make sure that they are studying for their test. I would say like the cooperative learning goal that I had down, really, really I use a lot just to kind of get the students working together and why they should be working together and just kind of how it all fits together. Be a good citizen. We’re always trying to make sure everyone’s getting along and getting their things done and you know. Another goal, is like, being responsible. Have them be responsible for their work and for what they’re doing in class... Another goal,...was like, hands-on, you know it’s hard to do that.”

High: Statement refers to several goals and the interactions between them.

Exemplar--

Teacher Behaviors and Strategies linked to Student Actions

Absent: Teaching behaviors and strategies are not addressed. OR Statement reduces teaching behaviors and strategies to classroom management.

Exemplars “Just watching them to make sure they’re on task.”

Low: Teaching behaviors and/or strategies are stated, but no explicit statements regarding a link to student goals is made. The link at best, is implicit.

Exemplar—“The easiest is questioning.”

Moderate: Statement articulates a moderate understanding of teaching behaviors and/or strategies and vaguely links them to student actions and/or goals.

Exemplar—“[To know if students are meeting my goals, I] ask them questions...try to get them to talk it out. Me just be the guide. The teacher...[is] the person who asks the questions and who gets the kids thinking.”

High: Statement articulates an understanding of teacher behaviors/strategies as a package and demonstrates how important they are for attainment of student actions and/or goals.

Exemplar—

Content, Materials and Activities linked to Student Actions

Absent: Statement fails to mention content/materials/activities of the lesson.

Exemplars—

Low: Content, materials and activities are stated but no explicit comments regarding the link to student actions/goals. The link is at best implicit.

Exemplar—

Moderate: A vague, general statement is made regarding the link to student action/goals.

Exemplar—

High: Makes a general statement, but explains the characteristics of activities, materials, or content that will elicit the desired student actions/goals.

Exemplars—“Students will be able to observe and experiment with the way cups roll down the ramp. They discover the ways that the cups move and roll.” OR “We have class discussions, they fill out journals about what they discover.”

Learning Theories linked to Teaching Behaviors and Strategies

The following categories are relevant for any one of the four learning theories of interest: Developmental, Social, Behavioral, and Constructivism.

Absent: The learning theory is not mentioned, or an articulation demonstrates absence of the link to learning theory.

Exemplar—“I haven’t had to use any theories, I mean I am sure I could pop some out, but I haven’t actually thought about the theories that would be involved.”

Low: Teacher indirectly articulates a link or directly articulates an incorrect use of the learning theory to select teaching behaviors and/or strategies.

Exemplar—“I also have a hard time letting the students take over and become independent learners as opposed to me feeding it into them. They learn better from themselves though! Learning is more meaningful that way.”

Moderate: Teacher directly articulates a link. Articulation may be vague or definitional, but it is correct.

Exemplar—

High: Teacher directly and accurately articulates a link that shows integration with goals and/or student actions and a deep understanding of how people learn.

Exemplar—

Learning Theory linked to Content, Materials, and Activities

The following categories are relevant for any one of the four learning theories of interest: Developmental, Social, Behavioral, and Constructivism.

Absent: The learning theory is not mentioned or the articulation demonstrates the absence of a link.

Exemplar—“I haven’t had to use any theories, I mean I am sure I could pop some out, but I haven’t actually thought about the theories that would be involved.”

Low: Teacher indirectly articulates a link or directly articulates an incorrect use of the learning theory to select content, materials, and activities.

Exemplar—“I gave them a point, their little rewards because they did well today listening.” OR “We didn’t talk about it together, but I figured if they talked to somebody, maybe that would help.”

Moderate: Teacher directly articulates a link but the articulation may be vague or definitional.

Exemplar—

High: Teacher directly articulates a link from learning theory to the selection of content/materials/activities that also demonstrates a deep understanding of how people learn.

Exemplar—“I don’t necessarily think that what the 4th graders were learning was at their level because they were struggling with being able to explain...it was a really big struggle to get them to understand what they couldn’t see. ...They understood that something was happening there...you can see something happening, but you don’t really understand why it is happening. So I think that was the biggest problem with teaching electricity.”

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