

Formative Assessment: Patterns, Personal Practice Assessment Theories,  
and Impact on Student Achievement and Motivation in Science

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## ABSTRACT

Formative assessment is a powerful educational tool that has the potential to raise student achievement if used appropriately in the classroom. Its first priority is to serve the purpose of promoting learning, in other words, it is assessment *for* learning, rather than assessment *of* learning. Formative assessment has potential to promote learning if it provides evidence used as feedback by teachers and by their students in assessing themselves and each other, to modify the teaching or learning activity in which they are engaged (Black and Wiliam, 1998).

The power of formative assessment to raise achievement is often overlooked in the current culture of high-stakes summative testing and accountability. This top-down approach to educational reform neglects one of the most important factors that affects learning - the teacher as facilitator of change. Teachers make instructional and assessment decisions based on experiences, knowledge, and beliefs, termed their personal practice assessment theories. However, those internally constructed elements are not alone in shaping their assessment decisions. Other external contextual elements have a profound effect on their decisions as well. Those internally constructed and externally imposed contextual elements influence the purpose, planning, and implementation of assessment, and subsequently impact student achievement and motivation to learn.

The purpose of this research study was threefold: first, to investigate the formative assessment practices of three biology teachers in context of their personal practice assessment theories. Second, to illuminate contextual elements that constrain or facilitate the use of formative assessment. These goals were accomplished through a collective instrumental case study and cross-case analysis. The third purpose of the

research was to determine the effect of formative assessment on student achievement and motivation, and was accomplished through quantitative measures.

The study showed distinct differences among the three teachers in the study regarding their personal practice assessment theories and use of formative assessment. Their theories developed through personal and professional experiences, were influenced by their beliefs about learners and learning, and were based on propositional, theoretical or strategic knowledge that played a critical role in converting theories about assessment into actual classroom practice. Several other factors were identified that facilitated or constrained the use of formative assessment. Student achievement and motivation was higher, and in many cases significantly higher in the class that embraced formative assessment compared to classes that did not.

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# CHAPTER I

## INTRODUCTION

In the late 1980's, Paul Black and Dylan Wiliam of King's College in London conducted extensive research to determine whether there was evidence that improving formative assessment increased student achievement. They reviewed over 160 journals from several countries during a nine-year period, and analyzed material from 250 of their sources, from which they chose 40 research studies for a detailed meta-analysis. Their answer was an unequivocal *yes*. Formative assessment practices led to significant and substantial gains in student learning. "There have been few initiatives in education with such a strong body of evidence to support a claim to raise standards" (2002, p. 9). Subsequent research studies (Black et al., 2002; G. T. L. Brown & Hirschfeld, 2007; Meisels et al., 2003; Rodriguez, 2004; M.A. Ruiz-Primo & Furtak, 2004) have clearly supported their claim.

The implementation of formative assessment in science education is dependent upon internally constructed contextual elements such as beliefs, values, knowledge, and experiences of the classroom teacher and influenced by externally imposed contextual elements such as state and federal mandates, school administration expectations and cultural norms of the school. Although there has been clear evidence that the implementation of effective formative assessment has the potential to improve student learning, there has been little evidence that it is being used by classroom teachers.



## Education Reform Background Information

Before the 20<sup>th</sup> century, instructionism was the predominant form of teaching in science classrooms (National Research Council, 2000). Instructionism, a phrase coined by Seymour Papert, refers to a transmission model of communication, in which a teacher instructs by transmitting facts to a passively receptive student. It describes an educational philosophy and family of practices based on the idea that you can improve education by teaching better (Cannings & Stager, 2003). During the 20<sup>th</sup> century, an epistemological shift from instructionism to a learner-centered, constructivist approach emerged. The following description characterizes the constructivist belief concerning learning:

Learning is not a passive process of transferring information from expert to novice. Rather, learning is an active process, employing a “learning by mindful doing” approach where learners must cognitively manipulate the material they are learning to create cognitive links from the new material to their own prior knowledge. (Quintana, Shin, Norris, & Soloway, 2006, p. 122)

Concurrent with the constructivist movement during the 20<sup>th</sup> century was the realization by the United States that our science education system was in need of serious reform. The launching of the Sputnik satellite by the Russians in 1957 served as a wake-up call to Americans and generated renewed interest and emphasis in science education. New curriculum was introduced that was more constructivist in nature with an emphasis on the processes of science as well as science content (National Research Council, 1996). By 1981, in response to the concerns by the public, Secretary of Education T. H. Bell created the National Commission on Excellence in Education, directing it to examine the quality of education in the United States and to make a report to the Nation. In 1983, the commission published *A Nation at Risk* that detailed for the American public the state of affairs in our educational system - which was considered mediocre at best,

and issued a call for serious reform (National Research Council, 1996). Among their findings was the recognition that the average achievement of high school students on most standardized tests was lower than 26 years ago when Sputnik was launched and that the slight gains made in the wake of the Sputnik challenge had been squandered (National Commission of Excellence in Education, 1983). Among many of their recommendations was a call for a Learning Society. At the heart of such a society was “the commitment to a set of values and to a system of education that affords all members the opportunity to stretch their minds to full capacity, from early childhood through adulthood, learning more as the world itself changes” (National Commission of Excellence in Education, 1983, Sec. 4). Cries for reform led to the development of more innovative science curricula and eventually a definition of scientific literacy for high school graduates outlined in the publication *Science for All Americans* (American Association for the Advancement of Science, 1989). Soon afterwards, content standards for science, math and technology were outlined in Project 2061’s *Benchmarks for Science Literacy* (American Association for the Advancement of Science, 1993) and standards for science education in content, teaching, professional development, assessment, programs and systems were developed and outlined in the National Research Council’s *National Science Education Standards* (National Research Council, 1996).

On January 8, 2002, in the wake of the standards-and-testing movement that ensued after *A Nation at Risk* was published, President George W. Bush signed into law the No Child Left Behind Act (NCLB) of 2001. The purpose of NCLB was to close the achievement gap with accountability, flexibility, and choice, so that no child is left behind (NCLB, 2002) and included a demand for qualified teachers for every child.

NCLB provided federal resources to states to improve low performing schools, and expected increased accountability in return, which led to a sharp increase in standardized testing in most states (Black & Wiliam, 2005; Chappuis & Chappuis, 2007; Nichols & Berliner, 2008).

### Statement of the Problem

There is evidence, which is too often overlooked, that classroom teachers play a critical role as facilitators of change (Battista, 1994; Cuban, 1990) and as a result, are a central component of educational reform (American Association for the Advancement of Science, 1989). Wenglinsky (2000) concluded, “Changing the nature of teaching and learning in the classroom may be the most direct way to improve student outcomes” (p. 11). Cuban (2007) asserted that teachers are the gatekeepers to learning in schools and crucial to the growth of our youth. Overall, it is quite evident that student learning and success are directly dependent upon what teachers do in the classroom (Hanushek, 2004).

Teachers enter the classroom with a set of personal theories, or constructs, based on beliefs, values, forms of knowledge, experiences and goals that have a profound effect on what and how they teach. However, these internal constructs are not alone in shaping instruction. Externally imposed factors “have a potentially powerful impact on teachers’ personal theories about both content and pedagogy and ultimately shape teaching practices” (Smith & Southerland, 2007, p. 400). Externally imposed factors include tools of reform such as national and state standards and related standardized tests, the physical environment of the classroom and school, the social interaction within the environment between teachers, students, administrators and parents, and the features that influence

interactions such as political, social and educational relationships, financial resources, and educational policies (Jones, 1997; Lave, 1991, 1993). Internally constructed theories and externally imposed factors combine to form a complex array of contextual elements that influence “the methodology a teacher utilizes, his or her instructional goals, and his or her beliefs and knowledge about subject matter and its relationship to what is appropriate or inappropriate to do with students” (Smith & Southerland, 2007, p. 400).

It is important to recognize how these contextual elements influence a teacher’s tendency to embrace reform approaches to teaching and learning including the implementation of formative assessment. In the current culture of federally mandated reform and emphasis on accountability, it is of particular interest to note that research showed that, in addition to raising student achievement in the classroom, formative assessment practices could also substantially improve student achievement on externally mandated standardized tests (Black & Wiliam, 1998b; Meisels et al., 2003; William, Lee, Harrison, & Black, 2004). However, valuing and implementing formative assessment practices may be at odds with teachers’ beliefs about the goal of classroom instruction, which is influenced by the emphasis on high-stakes testing and other contextual elements, and serve as an impediment to its adoption (Battista, 1994). This study investigated the dynamics between the formative assessment beliefs and practices of science teachers and the contextual elements that affected them, and the effect that those practices had on student achievement and motivation to learn.

## Rationale

Despite clear evidence that formative assessment practices improve learning, little research has been conducted that reveals what contextual elements impact the use of formative assessment or the extent to which it is actually implemented in the science classroom (Furtak, 2005). Black and Wiliam (1998b) described the classroom as a *black box* where inputs such as rules, resources, and high stakes tests from the outside were fed in to or demanded of the system. Outputs followed, such as test results, knowledgeable pupils and satisfied teachers. However, little is known with regard to what happened *inside*. “How can anyone be sure that a particular set of new inputs will produce better outputs if we don’t at least study what happens inside”(p. 1)? Many educators have called for more research of learning in context – a look at the typical classroom and the interactions between teachers and students that impact student achievement (Black & Wiliam, 1998b; Furtak, 2005; Kilpatrick, Martin, & Schifter, 2003; C. Leung, 2004; Wenglinsky, 2000) including contextual elements that impact the implementation of educational reform (Smith & Southerland, 2007).

Research of learning in context involves the effect that formative assessment has on students as well. The impact of formative assessment on student achievement has been well documented, but how it impacts their motivation to learn has not (B. Cowie, 2005). Researchers have established that students who are highly motivated tend to be successful academically (King, 2006). Therefore, investigating the interaction between teacher’s implementation of formative assessment and student motivation may illuminate factors that influence student achievement. “Assessment strategies that build academic

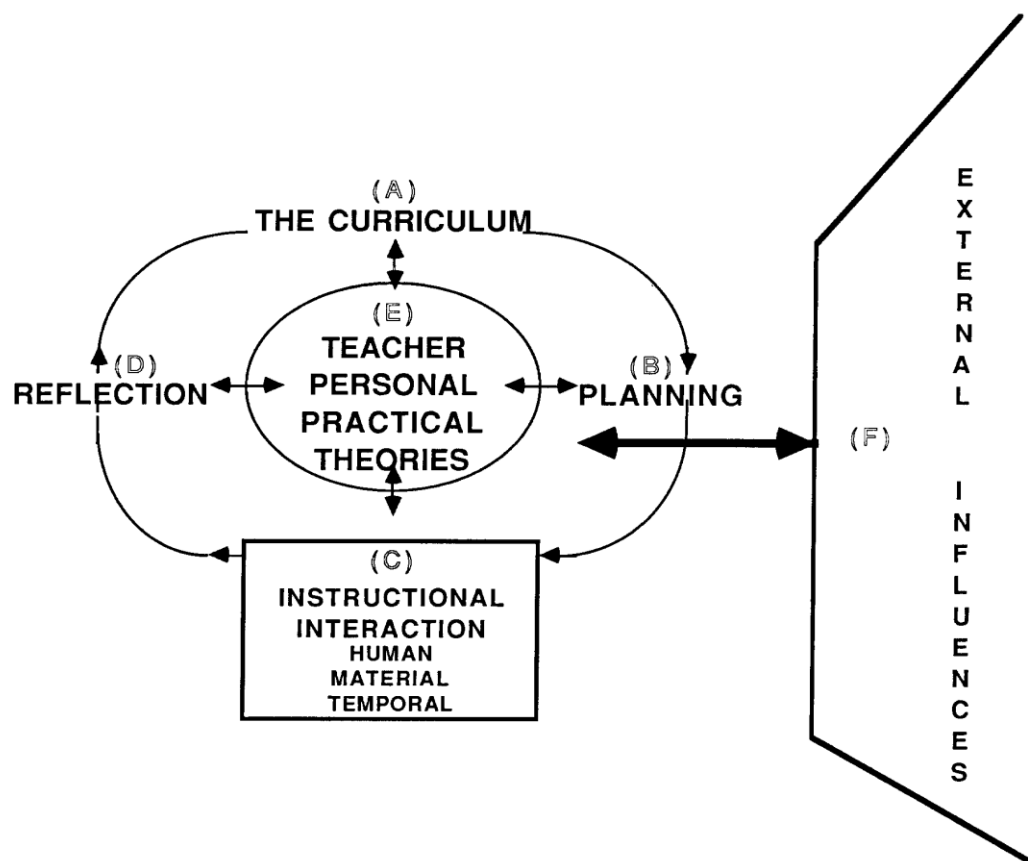
self-efficacy and motivation hold great promise as educational interventions” (King, 2006, p. 32).

### Theoretical Framework

In order to investigate formative assessment theories and practices of classroom teachers, Cornett’s (1990) model of personal practice theories (PPTs) was chosen as a framework. PPTs are “those systematic theories or beliefs held by each teacher that are based upon personal experiences derived from non-teaching activities (such as life as a student or parent) and practical experiences that occur as a result of designing and implementing the curriculum through instruction” (Cornett, 1990, p. 185). Personal practice theories guide teachers’ actions during the classroom and are formed over years of practice (Ritchie, 1998). Clandinin and Connelly (1996) contended that PPTs include a teacher’s tacit knowledge about content, pedagogy, curriculum, learners, educational aims and contexts, and pedagogical content knowledge. Teachers’ personal practice theories and other external contextual elements that may be beyond their control determine what happens in the classroom. Cornett (1990) offered a model that described the impact of a teachers’ PPTs when influenced by external factors on curricular and instructional decision making. See Figure 1.1. In this model, the teacher’s personal practice theories (E) influence their deliberations and decisions about what constitutes curriculum (A) for a particular subject and grade level. PPTs evolve as the teacher gains experience and as the context changes. As teachers plan (B), they are influenced by their PPTs, which are continually impacted by external contextual elements (F) which may include legislation, parents, administration, media, economics, and textbooks. The

external contextual elements that affect planning (B) also have a direct influence on the instructional interactional phase (C) during which students, teachers and subject matter interact. Throughout the interactions, the teacher reflects (D) on the enacted curriculum, which is, again, impacted by the teacher's PPTs and external forces. The reflection may or may not modify the teachers' PPTs and curriculum decisions for the future.

Figure 1.1: Cornett's 1990 curriculum development model based on the impact of PPTs



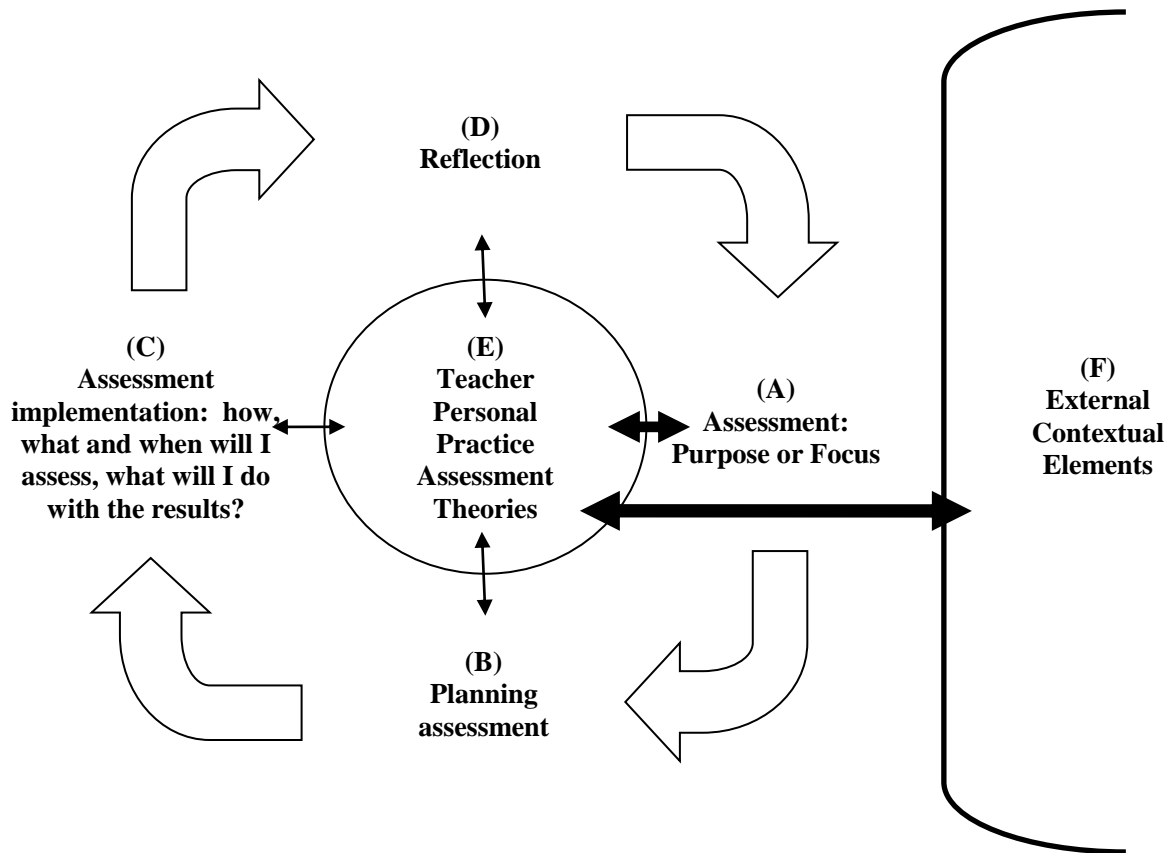
Cornett's model can be adapted to address teachers' assessment theories as well, termed their personal practice assessment theories (PPATs). As a basis for the teachers' personal practice assessment theories, Brown's (2003) four conceptions of assessment

can be applied to the development of PPATs. Brown contended that teachers may believe that: 1) assessment is useful in improving teacher instruction and student learning by providing quality information for decision-making, 2) assessment is about accountability of students through certification processes, 3) teachers or schools are made accountable through internal or external evaluations, or 4) assessment is irrelevant to the work of teachers and the life of students (p. 5). He pointed out that individual teachers' conceptions are typically composed of a complex combination of conceptions about the purpose and use of assessment practices, rather than a single one. It is my contention that these conceptions held by teachers are a result of their beliefs, values, goals, experiences and knowledge of assessment and contribute to their personal practice assessment theories. See Figure 1.2. In this model, the teachers' personal practice assessment theories (E) influence their decisions about the purpose (A) of the assessment activity. Does the teacher enact assessment because s/he believes it necessary for certification and accountability purposes (summative assessments), for guiding future instruction (formative assessment), to fulfill a school mandate, as a habit or standard classroom procedure or for a combination of reasons? The intent and purpose of assessment (A) is influenced by both their PPATs and external contextual elements (F). These external contextual elements may be policies such as mandated high-stakes testing, administration, parents, and other factors. As teachers plan (B) their assessment, they are influenced by their PPATs and the purpose, focus and intent involved, which have a direct influence on what is assessed, methods of assessment used and when assessment is implemented (C). The implementation phase involves decisions with regard to how teachers will use the results of the assessment. Throughout the interactions, the teacher



reflects (D) on the effectiveness of the assessment activity, which in turn, may modify their PPATs and assessment decisions for the future.

*Figure 1.2: Assessment development model based on the impact of PPATs and external contextual elements. Modified from Cornett's (1990) curriculum development model*



### Purpose of the Study and Research Questions

The purpose of this study was to look inside “the black box” and investigate the purposes and implementation of formative assessment practices of secondary science teachers in context of their personal practice assessment theories, to illuminate internally constructed and externally imposed contextual elements that affected them, and to

determine how classroom practices including formative assessment affected student achievement and motivation. In particular, this study focused on the following questions:

- 1) What formative assessment practices do individual teachers use in the science classroom?
- 2) What personal practice assessment theories influence the implementation of formative assessment by individual science teachers?
  - a. What do individual teachers expect to achieve using specific formative assessment practices?
  - b. What contextual elements constrain or facilitate the use of formative assessment by individual science teachers?
- 3) To what extent does formative assessment affect student achievement and motivation in the typical science classroom?

### Significance of the Study

Educators, parents, business leaders and policy makers constantly strive to improve education for all students. Billions of dollars are spent each year in this endeavor, yet improvement in science education is marginal (Davis, 2003; Linn, 2000; National Center for Educational Statistics, 2004; Nichols & Berliner, 2008). “America has spent 60 years building layer upon layer of district, state, national, and international assessments at immense cost – and with little evidence that our assessment practices have improved learning” (Stiggins, 2007, p. 1). In order to improve education, it is imperative that we learn more about the teacher as a gatekeeper of knowledge and facilitator of

change, and develop a deeper understanding of what influences their classroom assessment practices.

Classroom researchers have argued that it is important to understand the complexities of classroom teaching and learning before it is possible to generate hypotheses about effective practice, theorize about the limitation of current classroom practice and inform beginning teachers about effective practice. (Ritchie, 1998, p. 2)

There is convincing evidence that formative assessment practices can help students make substantial gains in learning. Therefore, identifying and analyzing teachers' personal practice theories related to formative assessment and the frequency and manner in which they use assessment in a given science classroom will serve as a starting point in determining what steps need to be taken to enhance those practices. Leung and Mohan (2004) contended that:

There is a need to examine in depth the formative teacher for-learning assessment issues in their own right if we are to understand how the formative aspects are actually accomplished in the classroom interaction, and if we are to develop appropriate theory and research methods in the study of this highly complex and dynamic aspect of teaching-learning interface. (p.337-8)

Furthermore, investigating the complex terrain that teachers negotiate as they make educational decisions regarding assessment practices has the potential to illuminate contextual elements that should be reduced if they constrain, or enhanced if they facilitate, the proper implementation of formative assessment practices.

### Definition of Terms

*Formative assessment*, as described by Black & Wiliam (1998b) refers to “all those activities undertaken by teachers, and by their students in assessing themselves, which provide information to be used as feedback to modify the teaching and learning

activities in which they are engaged. *Such assessment becomes 'formative assessment' when the evidence is actually used to adapt the teaching work to meet the needs"* (p. 2).

*Theories*, as used in this context describe possible underlying mechanisms that regulate human learning, development and behavior (Ormrod, 2003) and are formed through experiences and guided by beliefs and forms of knowledge.

*Contextual elements* are all the factors that affect teaching including teacher internally constructed beliefs, knowledge, values, and goals, that coalesce to form their *personal practice theories*, as well as the externally imposed factors including national and state standards and state mandated tests, physical space of the school environment, social interaction and relationships between teachers, students, administrators and parents, financial resources, educational policies, the culture and norms of the school environment that impact their personal practice theories.

*Personal Practice Assessment Theories (PPATs)* are "the conceptual structures and visions that provide teachers with reasons for acting as they do, and for choosing the teaching activities and curriculum materials they choose in order to be effective. These are the principles or propositions that undergird and guide teachers' appreciations, decision, and actions" (Sanders & McCutcheon, 1986, p. 55) regarding assessment.

### Assumptions

Certain assumptions underlie the development and analysis of the current study.

- Federal and state mandates influence the instructional decisions teacher's make.
- Teachers care about student learning and reflect on practices that affect it.
- Teachers must be dissatisfied with the status quo in order to implement change.

- Personal practice assessment theories held by teachers influence their decisions in the classroom.
- External factors influence a teacher's personal practice assessment theories and therefore their decisions in the classroom.

CHAPTER II  
LITERATURE REVIEW

History of Formative Assessment

Michael Scriven (1967) first coined the terms formative and summative evaluation in the context of curriculum evaluation. He stated:

[Evaluation] may have a role in the on-going improvement of the curriculum, and with respect to this role several types of questions (goals) may be raised...In another role, the evaluation process may serve to enable administrators to decide whether the entire finished curriculum, refined by use of the evaluation process in its first role, represents a sufficiently significant advance on the available alternatives to justify the expense of adoption by a school system...I propose to use the terms 'formative' and 'summative' evaluation to qualify evaluation in these roles. (p. 41)

Bloom, Hastings, and Madaus (1971) however, were the first to expand the use of the terms formative and summative evaluation into what is now considered their generally accepted meanings. They defined summative evaluations as those conducted at the end of a unit or course to determine how much students know, or for the purpose of grading, certification, evaluation of progress, or even for researching the effectiveness of a curriculum. They contrasted summative evaluations with those in which both students and teachers welcomed the evaluations because they found them useful in helping them improve what they wanted to do (p.117) which they called "formative evaluation."

By 1989, the American Association for the Advancement of Science (AAAS) released *Science for All Americans* (1989) that promoted the idea that what students learn is influenced by their existing ideas and stressed the importance of informative feedback. The NRC (1996) encouraged educators to continually make adjustments to their teaching on the basis of their interpretation of information gained during informal assessment – a

hallmark of formative assessment. They also promoted the idea that teachers should provide students the opportunity to self-assess to enhance self-directed learning. Although neither the AAAS nor the NRC specifically used the term “formative assessment,” these concepts are consistent with important attributes of formative assessment. However, the power of formative assessment received little attention until Paul Black and Dylan Wiliam published *Assessment and Classroom Learning* in 1998. Black and Wiliam began by reviewing two critical articles (Crooks, 1988; Natriello, 1987) to serve as a baseline for their study. They subsequently reviewed over 160 journals from several countries during a nine-year period. Their analysis of material from 250 of their sources led them to conclude that formative assessment was clearly a means to improve student achievement. A National Research Council (NRC) report (2000), which emphasized the importance of formative assessment in the science learning environment, cited Black and Wiliams’ (1998b) research in describing how self-assessment by students, and conversations instead of inquisitions, were critical attributes of formative assessment. The NRC report (Bransford, Brown, & Cocking, 2000; National Research Council, 2005) promoted formative assessment as a key attribute in a learning environment and noted the need for an increase in the frequency and effective use of formative assessment in the classroom.

Since then, other prominent educational entities have initiated reform efforts to promote formative assessment. For example, the Educational Testing Service in Princeton, N.J. recently acquired the Assessment Training Institute, whose goal is to provide seminars, school improvement professional services and professional development programs aimed at improving the use of formative assessment to support

student learning. A position paper of the National Science Teachers Association (NSTA) noted the importance of formative assessment and stated “when the outcomes of learning are clearly specified, as they are in the NSES, assessment can and should be used as feedback to improve the learning/teaching process as well as to determine if students are achieving the desired outcomes” (National Science Teachers Association, 2003, par. 11). This position paper cited Black and Wiliam’s conclusion that formative assessment used frequently as feedback to individual students is one of the most effective strategies available to teachers in meeting high standards of student learning. The inclusion of formative assessment as a topic in many of the organization’s conference sessions, books and journal articles reflects NSTA’s recognition of the importance of formative assessment in education reform.

The National Academies and the National Research Council, in their description of educational reform in *Taking Science to School: Learning and Teaching Science in Grades K-8* (2007) outlined the importance of formative assessment as one of their major finding and conclusions of research with regard to how students learn. Conclusion 12 stated that:

Ongoing assessment is an integral part of instruction that can foster student learning when appropriately designed and used regularly. Assessment, whether formative or summative, needs to be responsive to the full range of proficiencies that are implied by the strands. Assessment needs to be aligned with the research on students’ thinking as well as informed by the subject matter. (p. 344)

They call for individual teachers, administrations and school systems to implement well-designed assessments stating that they “can have a tremendous impact on students’ learning of science if conducted regularly and used by teachers to alter and improve instruction” (p. 344).



The Biological Sciences Curriculum Study (BSCS) included an emphasis on formative assessment as an integral part of science education reform in their National Academy for Curriculum Leadership (NACL) professional development initiative. The 3- year NACL program for school and district leadership teams trained educational leaders in the implementation of research based instructional methods and materials including the use of formative assessment.

#### Formative Assessment and Learner-Centered Environments

Bransford, et al. (2000) described how learning environments should be designed to meet the needs of all students. Within that design is a focus on the student - their knowledge, skills, attitudes, and beliefs, which they termed a learner-centered environment. In their description of a learner-centered environment, they stressed that the teacher pays attention to preconceptions of the students, begins with what students think and know, makes connections between previous knowledge and current academic tasks, and builds on strengths, interests and needs of the learner. The classroom is characterized by frequent teacher-student dialogue to monitor student thinking. The teacher closely monitors the individual progress of each student and devises appropriate tasks. Teachers are aware that students construct their own knowledge and teaching constructs a bridge between subject matter and students. This description of a learner-centered classroom makes it clear that a classroom environment cannot be considered learner-centered without the use of formative assessment. Formative assessment is related to a learner-centered classroom and a learner-centered classroom depends on formative assessment.

## Evidence of the Impact of Formative Assessment on Student Achievement

Key findings and studies cited in Black and Wiliams' *Assessment and Classroom Learning* (1998a) are as follows:

A Portuguese study (Fontana & Fernandes, 1994) involving 25 mathematics teachers, who were trained in self-assessment methods, put them into practice with 354 students ranging in age from eight to fourteen. In comparison with a control group of younger students, the mean gain for the younger students in this sample was about twice that of the control group of younger students. Older students' results were less clear.

A study by Whiting, et al. (1995) reported on the implementation of mastery learning with approximately 7000 students over an 18 year period. Mastery learning involved regular testing and feedback, as students were required to achieve 90% mastery or other mastery criterion before proceeding. In this study, the final test scores and the grade point averages of the students in classes using mastery learning were consistently high, and higher than those of students in the same course not using mastery learning.

A study by Martinez and Martinez (1992) of 120 American college students in an introductory algebra course revealed that students who were tested more frequently made significant gains over those who tested less frequently, although there were some questions about how the quizzes were used in a formative sense.

A study of 838, 5-year-old children (Bergan, Sladeczek, Schwarz, & Smith, 1991) in the U.S. revealed that the use of a measurement and planning system resulted in significant gains in reading, math and science for an experimental group compared to a control group. The teachers of the experimental group began by assessing initial knowledge of the students to inform teaching at the individual level. Then every two

weeks, they would re-assess to identify where students were along the learning continuum and adjust teaching accordingly.

Butler (1988) studied 48, 11-year-old Israeli students, half of which were in the top quartile of their class and half of which were in the bottom quartile. Students were given written tasks and then provided feedback in one of three ways: 1) comments only, 2) numerical grades only and 3) comments and numerical grades. Results showed that both high and low students made significant gains on all three tasks when receiving comments only. “Numerical grade only” students’ achievement declined on two of the three tasks and “comments with grades” students declined on all three tasks. They stated:

...the only significant difference between the high and low achieving groups was that interest was undermined for the low achievers by either of the regimes involving feedback of grades, whereas high achievers in all three feedback groups maintained a high level of interest. (p. 7)

In a U.S. study of 9 and 10-year-olds (Schunk, 1996), 44 students were separated into two groups, one that stressed learning goals (learn how to solve problems) and one that stressed performance goals (merely solve them). The learning goals group was guided to use frequent self-evaluation, but the performance goals group was not. The learning goals group showed significantly higher motivation and achievement than the performance goals group.

Frederiksen and White (1997) conducted a study of an inquiry-based middle school science curriculum that, during the course of the unit, the control group was involved in traditional discussions while the experimental group was guided to use discussions that promoted reflective assessment with both peer-assessment of presentations to the class and self-assessment. The experimental group showed significant gains over the control group on project scores. Interestingly, “low” ability

students showed superiority over their control group peers, of more than three standard deviations, the “medium” ability students just over two, and the “high” ability students just over one.

These studies provided convincing evidence that strengthening the practice of formative assessment produced significant, and often substantial, learning gains. In fact, the mean effect sizes for most of these studies were between 0.4 and 0.7. “Such effect sizes are among the largest ever reported for sustained educational innovations” (Black, Harrison, Lee, Marshall, & Wiliam, 2003, p. 9). Of particular interest, is that so-called low achievers improved a great deal, thereby reducing the gap between low and high achievers.

Other studies conducted since the release of Black and Wiliams’ research supported findings that formative assessment practices improved achievement and are summarized as follows.

A research initiative by the King’s-Medway-Oxfordshire Formative Assessment Project in London showed that students in their study made significant gains in achievement when teachers implemented formative assessment strategies. The intervention resulted in an average effect size of approximately 0.3, which translated to raising achievement from the lower quartile in national performance to well above average (Black et al., 2002).

Meisels, et al. (2003) examined the Iowa Tests of Basic Skills scores of third and fourth graders who had been involved in a Work Sampling System (WSS) program that promoted a curriculum-embedded performance assessment compared to a demographically comparable contrast group. Research indicated that:

...students who were in WSS classrooms displayed growth in reading from one year to the next that far exceeded the demographically matched contrast group as well as the average change shown by all other students in the district. Children in WSS classrooms made greater gains in math than children in the other two groups, although the results were only marginally significant when compared with gains by the matched contrast group. Effect sizes ranged from .75 to 1.5 standard deviations. (p. 2)

Rodriguez (2004) evaluated the relationship between assessment practices and achievement of U.S. mathematics students involved in the Third International Math and Science Study (TIMSS) and found that teacher assessment practices had significant positive relationships to classroom performance. In particular, he concluded that teachers could help students, especially low performers in mathematics, believe that they could control their own success in learning.

William, Lee, Harrison and Black (2004) monitored the achievement of math and science students in the classrooms of 24 teachers (12 math and 12 science teachers) who were supported over a six-month period to explore and plan their approach to implementing formative assessment. Rather than prescribe specific practices for teachers to implement, the teachers and experts collaborated in the decision making process. The experts shared their knowledge regarding effective practices with the teachers, but the teachers individually selected and utilized formative assessment methods that complimented their teaching styles and personal preferences. Those practices were implemented and the mean effect size in favor of the intervention was 0.32 compared to a control group.

Research by Wilson and Sloane (2000) provided evidence that students with teachers who were trained to use a structured embedded assessment system, known as the BEAR (Berkeley Evaluation and Assessment Research) assessment system made

significant gains in achievement compared to a control group who had not been trained. Gains for students in the intervention group were 3.46 times greater than those in the control group.

Project MUSE (Modeling for Understanding in Science Education) researchers determined how formative assessment practices benefited a group of students and teachers during an evolution course that was designed to help students use models to understand natural selection (Passmore & Stewart, 2006). The researchers wanted to determine what types of assessment would benefit students as they learned, and at the same time, provide feedback to teachers to help them improve the course. They learned that assessment tasks that allowed students to have repeated opportunities to receive feedback from their teacher and peers concerning their developing abilities, helped students make significant gains in their understanding of evolution principles. The insight provided by student data served as a baseline for analysis for teachers and shaped their future instruction.

Ruiz-Primo and Furtak (2004; 2007) studied the informal formative assessment practices of three science teachers and their classrooms as they implemented a physical science curriculum in buoyancy. Informal formative assessments are those that produce evidence of learning in the course of the day-to-day activities, as opposed to planned or formal formative assessments. In this instance, the researchers studied the informal formative assessment conversation strategies of teachers including the occurrence of their eliciting, recognizing and using information from their students. Teacher strategies were tracked and results showed that the use of informal formative assessment conversation

strategies of one of the teachers led to significantly higher student performance than their counterparts who neglected to implement such strategies.

Fox-Turnbull (2006) studied technology students as they participated in technological tasks and examined the effect of teacher knowledge on formative assessment feedback provided to students. She found that teacher intervention through formative assessment practices, including asking higher-level thinking and/or open-ended questions that challenged the students to extend their thinking improved students' technological design. She concluded that teacher knowledge had an impact on the use and quality of formative assessment and therefore affected students' practice and achievement.

#### Formative Assessment and Student Motivation

Student partnership in the learning and assessing process is an integral part of formative assessment. Students who are intrinsically motivated undertake learning for its inherent interest or enjoyment, rather than for external rewards (Vansteenkiste, Lens, & Deci, 2006). Increased motivation is one of the mediating factors that links assessment practices to student academic success in a formative assessment classroom. Howe (1987) explained the impact of motivation on achievement by stating:

I have a strong feeling that motivational factors are crucial whenever a person achieves anything of significance as a result of learning and thought, and I cannot think of exceptions to this statement. That is not to claim that a high level of motivation can ever be a sufficient condition for human achievements, but it is undoubtedly a necessary one. And conversely, negative motivational influences, such as fear of failure, feelings of helplessness, lack of confidence and having the experience that one's fate is largely controlled by external factors rather than by oneself, almost certainly have effects that restrict a person's learned achievements. (p. 142)

Although classroom assessment is not the only factor that affects student motivation, research by Hill and Hawk (2000) regarding effective classroom practices and student motivation provided evidence that students are motivated when the locus of control is shared with the teacher and when they have visible evidence that they are making progress with their learning - attributes of formative assessment. However, “little is known about student perceptions and experiences of everyday classroom formative assessment” (B. Cowie, 2005, p. 200).

### What Formative Assessment Looks Like in the Classroom

After Black and Wiliam made their case concerning the importance of formative assessment, they published *Working Inside the Black Box*, (2002) which provided educators practical steps to implementing formative assessment practices in their classrooms. In this publication, they expanded the description of formative assessment:

Assessment for learning is any assessment for which the first priority in its design and practice is to serve the purpose of promoting pupils’ learning. It thus differs from assessment designed primarily to serve the purposes of accountability, or of certifying competence. An assessment activity can help learning if it provides information to be used as feedback, by teachers and by their pupils in assessing themselves and each other, to modify the teaching and learning activities in which they are engaged. Such assessment becomes ‘formative assessment’ when the evidence is actually used to adapt the teaching work to meet learning needs.  
(inside cover)

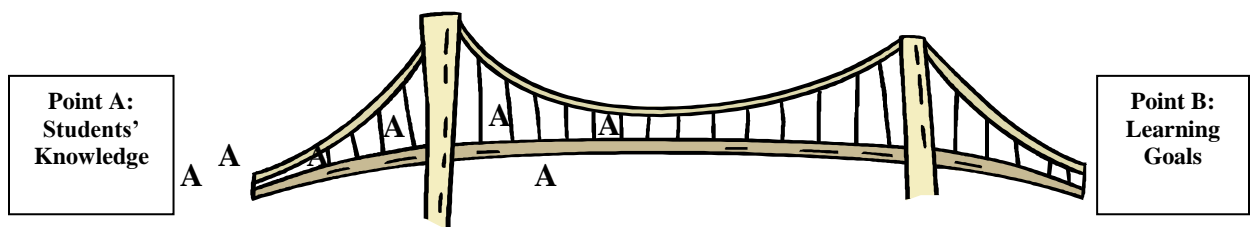
An emphasis is placed on the actions that teachers and students take as a result of the formative assessment practices. What is revealed during learning must “form” what they are preparing to do next as they strive to meet their learning goals. Another important aspect of formative assessment is the role of the student. Each student should have ownership and a degree of control of his or her own learning with the help and guidance



of the teacher. In order for this to take place, students and teachers need to: 1) establish the students' current level of understanding before instruction begins, 2) determine and understand the learning goals, and 3) continually know where students are in relation to their learning goals and what it is going to take to reach them.

Marie Furtak (2005) used a bridge metaphor to help conceptualize the role assessment can play in helping students achieve learning goals. In this bridge metaphor, one side of the gap represents the current place where students sit (Point A) and the other represents student learning goals (Point B), and the distance between points A and B comprises a gap that needs to be bridged (see Figure 2.1). Teachers must know where each student's 'Point A' is when instruction begins. Then, to establish the size of the gap, the teacher must make the students' thinking visible so that their level of understanding can be compared to the goal – 'Point B'. "While the gap metaphor lacks the complexity inherent in any classroom activity, it does capture the possibility of how assessment can provide teachers and students with information that can inform actions that bridge the gap" (Furtak, 2005, p. 6).

*Figure 2.1:* A visual representation of the learning bridge as described by Furtak, 2005.



## Determining Point A

According to Bransford, et al. (2000) “Humans...come to formal education with a range of prior knowledge, skills, beliefs, and concepts that significantly influence what they notice about the environment and how they organize and interpret it” (p.10) and as a result, “teachers must draw out and work with the preexisting understandings that their students bring with them” (p.19) through formative assessment practices. These authors concluded:

Formative assessments—ongoing assessments designed to make students’ thinking visible to both teachers and students—are essential. They permit the teacher to grasp the students’ preconceptions, understand where the students are in the “developmental corridor” from informal to formal thinking, and design instruction accordingly. (p. 24)

There is general agreement that many students hold ideas concerning scientific principles that are not in agreement with scientifically acceptable conceptions. These are commonly referred to as misconceptions, or “alternative conceptions.” For example, many students believe that shadows cast on the moon by the earth cause lunar phases. If this misconception is not revealed to both the student and the teacher early on, it can impair the proper building of knowledge regarding how phases are the result of the positions of the Earth, moon and Sun. Formative assessment practices can help reveal these alternative conceptions as well as any current knowledge students may bring to the learning table.

There is a good deal of evidence that learning is enhanced when teachers pay attention to the knowledge and beliefs that learners bring to a learning task, use this knowledge as a starting point for new instruction, and monitor students’ changing conceptions as instruction proceeds. (Bransford et al., 2000, p. 11)

It is important to determine where students are in their learning throughout the lesson, not just at the beginning, so that lessons can be adjusted in a responsive and timely manner.

Some practical ways teachers and students can determine Point A include KWLs [what I know, what I wonder, what I learned] – (see Ogle, 1986 for a description), brainstorming, concept maps, surveys, formative assessment probes (see Keeley, Eberle, & Farrin, 2005), anticipation guides, presentations, frequent quizzes, and one-minute or exit cards. Informative classroom conversations that include asking probing and open-ended questions, and carefully listening to student responses, with extensions to verify and clarify student thinking as needed are also means of determining Point A. Wait time is important during the conversation to allow the students time to formulate an answer and to extend their thinking and elaborate on their responses (Black et al., 2002). Point A is not only determined at the beginning of a lesson, but also should be done throughout, until learning goals have been met. Self-assessment by students also helps reveal Point A. For example, students can “traffic light” their work (Black et al., 2002). In this activity, students assess where they are in learning by coding their work green, yellow or red according to whether they think they have good, partial or little understanding. Teachers and students then respond, especially to the yellow and red items. Students should be encouraged to reflect on where they are in relation to their goals on a continual basis. It is important to note that the classroom climate must be such that students feel comfortable asking questions and making public what they know and do not know.

### Determining and Recognizing Point B

Researchers and other educational experts agree (Black, 2004; Davies, 2003; Fontana & Fernandes, 1994; Frederiksen & White, 1997; Hall & Burke, 2003; National Research Council, 2000; Sadler, 1989) that learning goals should be explicit. It is

unreasonable to ask students to embark on a learning journey when they do not know where the end is, how to get there, or what it will look like when they do get there. To make learning goals explicit, students should have a participatory role in setting goals when possible or deciphering ones that have been set for them. They should have a clear picture of the criteria used to judge whether they have met their goals. Their learning goals should embody understanding as well as knowledge. As Wiggins and McTighe (2005) attested the word “understanding” has various meanings and goes beyond knowledge. They used seminal work by John Dewey and Benjamin Bloom to describe understanding:

To grasp the meaning of a thing, an event, or a situation is to see it in its relations to other things: to see how it operates or functions, what consequences follow from it, what causes it, what uses it can be put to. In contrast, what we have called the brute thing, the thing without meaning to us, is something whose relations are not grasped...the relation of means-consequence is the center and heart of all understanding. (Dewey in *How We Think*, 1933)

Understanding is the ability to marshal skills and facts wisely and appropriately, through effective application, analysis, synthesis, and evaluation. Doing something correctly, therefore, is not, by itself, evidence of understanding. It might have been done by accident or done by rote. To understand is to have done it in the right way, often reflected in being able to explain why a particular skill, approach, or body of knowledge is or is not appropriate in a particular situation. (Bloom in *Taxonomy of Educational Objectives*, 1956)

Learning with understanding is one of the ultimate aims of education. In order for students to achieve understanding, learning goals (Point B) should be set accordingly.

Determining Point B is a joint effort between teachers and students. In most cases, external entities have outlined learning goals in the form of mandated standards. To help students understand these goals, Black et al. (2002) suggested allowing students to rewrite them in “kid-friendly” language. When possible, students should set personal

learning goals aligned with the content and purpose of the course. To help students understand the criteria against which their learning goals will be judged, they should be involved when possible, in setting the grading criteria as a rubric or scoring guide is developed. The process of developing the rubric helps them conceptualize what is valued and what success looks like. Rubrics should be developed and provided to students before they begin the learning task so that they have a clear picture of learning expectations. If the grading criteria are predetermined, students should still spend time studying the criteria that has been set for them. They should examine samples of exemplary work and less-than-satisfactory work so that they know what success looks like. Opportunities for self- and peer-assessment using rubrics should be structured into the lesson and students must be supported through the process as they learn to judge the quality of their work. Not only does self-assessment help students determine Point A, the reflection involved helps clarify what Point B looks like. Peer-assessment also reaffirms for the students what their success should look like as they analyze their peer's work.

Black (2002 p. 13) also suggested allowing students the opportunity to generate test questions inasmuch as “preparation of test questions calls for, and so develops, an overview of the topic” as well as helps provide a link between summative and formative evaluations.

### Bridging the Gap

Before students can bridge the gap between Point A and Point B, they must have a clear understanding of each. Once those points are identified, it is the teacher's responsibility to help students form an action plan to reach their goals. In particular,

teachers must continually listen and recognize where students are in their journey and adjust instruction accordingly. They must provide meaningful learning experiences that help them construct knowledge congruent with their learning goals and ensure that they learn with understanding. Students must continually receive feedback from the teacher that answers three questions: 1) What are the goals? 2) What progress is being made toward the goal? and 3) What activities need to be undertaken to make better progress? (Hattie & Timperley, 2007). The power of feedback has been well documented as crucial to improving knowledge and skill acquisition and to motivate learning (Hattie & Timperley, 2007; Shute, 2008). Students should continue to reflect on their goals based on feedback from the teacher and assess themselves and each other to monitor their progress as they move from Point A to Point B. Teachers should rely on feedback from students as they adjust the learning experience to maximize success (Wiggins & McTighe, 2005). This process will help the teacher reflect and adjust instruction – a defining characteristic of effective formative assessment.

William and Leahy (2006) summarized five key strategies of formative assessment as:

1. Clarifying and sharing learning intentions and criteria for success
2. Engineering effective classroom discussions, questions, and learning tasks
3. Providing feedback that moves learners forward
4. Activating students as instructional resources for one another, and
5. Activating students as the owners of their own learning

## Research on Current Use of Formative Assessment in the Classroom

Very little research has been conducted that reveals the extent that science teachers implement formative assessment practices in their classrooms. Ruiz-Primo and Furtak (2004; 2007) researched informal formative assessment questioning strategies utilized by three science teachers and found that it is more common for these teachers to elicit information from students than to recognize and use the information to improve student learning. Of the three teachers studied in depth, only one teacher routinely elicited, recognized and used the information students provided to inform her instruction.

A case study conducted by Treagust, Jacobowitz, Gallagher and Parker (2001), examined the work of an 8<sup>th</sup> grade science teacher as she taught a unit on sound. They found that the teacher used ongoing embedded assessment to inform her teaching and that most activities she implemented had an assessment component integrated into it. They stated that her “students had a wide range of opportunities to express their knowledge and understanding through writing tasks and oral questioning, and that individual students responded to and benefited from the different assessment techniques in various ways” (p. 137). This teacher had been involved in a Professional Development Schools program that trained her in the use of embedded assessment, which she implemented into her instruction. She noted that the professional development training she had been involved in had noticeably changed how she taught and assessed students.

Cowie and Bell (1999) analyzed formative assessment in ten science classrooms and focused on 1) the views of assessment held by teachers and students, 2) classroom activities relating to assessment, and 3) professional development on classroom-based assessment as a means to discuss emerging models of formative assessment. One of the

key findings of the research led to a model to describe and explain formative assessment as carried out by the teachers, which included planned and interactive formative assessment.

Duschl and Gitomer (1997) investigated assessment conversation strategies, defined as a “specially formatted instructional dialog that embeds assessment into the activity structure of the classroom” (p. 39) of teachers in a Science Education through Portfolio Instruction and Assessment (SEPIA) program. They focused on how teachers receive, recognize and use information during classroom conversations during a specific science unit where those particular strategies had been purposefully embedded. They identified pitfalls and challenges teachers face in implementing such strategies and made suggestions for overcoming them.

### Teachers as Facilitators of Change

Classroom teachers play a pivotal role between what needs to be learned and the learner. As a cornerstone of formal education, the classroom teacher makes curricular decisions that impact what, how and if students learn. Evidence suggested that the teacher effect on learning is substantial and perhaps greater than effects such as class size or socioeconomic factors (William & Leahy, 2006). Teachers are the ultimate interpreters of any classroom-based intervention, and are responsible for the variance in the effects of instructional interventions – known as the “teacher effect” (Fishman & Davis, 2006). However, if teachers are going to consider changing how they teach and assess, there must be some level of dissatisfaction. Feldman’s model of practical conceptual change (Feldman, 2000) demonstrated that teachers can and do change if there is a level of



discontent on their part. However, if teachers are content with the status quo, it is unlikely that they would see any rational reason for changing what they do. Sanders and McCutcheon (1986) attested that teachers informally use what is termed “practice-centered inquiry” when they are dissatisfied with the outcomes of learning. In practice-centered inquiry, the teacher reflects on learning outcomes and, if they are not pleased, may decide on a new approach to be taken the next time. However, a new teaching idea must survive the conceptual test of comparing it to what else they know, and then the teacher may make a decision to explore the new practice and decide if it is effective or not (p. 65). This practice-centered inquiry is necessary for reform. Teachers must reflect on their current classroom assessment systems and decide if they are effective in determining what students know and understand. If their current practices are not effective, reformed practices should be considered, implemented and reflected upon as the means to achieve improved results.

If reform assessment practices are going to become a reality, it is clear that the classroom teacher holds the key to its success. Therefore, attention must be paid to the teacher as facilitator of change. “Ignoring the role of teachers in the process of change is likely to doom reform efforts to failure” (Smith & Southerland, 2007, p. 397).

### Reform and Personal Practice Theories

Unfortunately, federal reform efforts have not substantially improved achievement in science education. This lack of progress is partly caused by the emphasis that has been placed on accountability and summative testing (Stiggins, 2002) instead of

on the most critical factors to learning: classroom teachers and the context in which they work. Smith and Southerland (2007) contended that:

Despite evidence that effective school change and new program implementation is more dependent on local elements within particular contexts (e.g., the classroom teacher, school administrative support, available resources, etc.) than on federal mandates or other top-down methods of promotion, reform efforts have traditionally neglected or undervalued the effects of such factors. (p. 397)

Reform efforts that *have* targeted classroom teachers however, have led to mixed results. Smith and Southerland (2007) reported that some teachers openly embraced reform-oriented practices while others did not. They indicated that “reform efforts are largely dependent on teachers’ ability or inability to modify their fundamental or central beliefs about what it means to teach and to learn” (p. 398). Implementing formative assessment practices are no exception. Black and Wiliam (1998a) noted that the implementation of formative assessment calls for deep changes in how teachers view their role as a teacher in relation to their students and to classroom practice. In other words, they must alter their personal practice theories.

Personal practice theories are “the conceptual structures and visions that provide teachers with reasons for acting as they do, and for choosing the teaching activities and curriculum materials they choose in order to be effective. These are the principles or propositions that undergird and guide teachers’ appreciations, decision, and actions” (Sanders & McCutcheon, 1986, p. 55). PPTs have a “powerful and constraining impact on instructional practice” (Gess-Newsome, Southerland, Johnston, & Woodbury, 2003).

Teacher PPTs are as unique as fingerprints. For example, the PPTs of a teacher in a research study conducted by Cornett, et al. (1990) included (in the teacher’s own words) the importance of 1) visual learning, 2) talking in kids’ terms, 3) science learning

as fun, 4) higher level learning, 5) very disciplined class, 6) reinforcing concepts, and 7) helping students save face. These were the seven personal practice theories that she claimed guided her practice and influenced decisions she made with respect to curriculum and instruction. The researchers in this study noticed that several of the PPTs often interacted at any one time during classroom instruction. Another science teacher in a study by Sweeney, et al. (2001) held very different PPTs including (his words), 1) every student is a scientist, 2) science requires research, 3) students must learn and practice a form of the scientific method, 4) essential factors in a positive classroom learning environment include discipline and good order, 5) the classroom environment is critical to a positive, productive learning effort, 6) teacher equals motivator, 7) don't waste time, 8) students need a challenge and 9) real-world applicability is part of understanding the importance of science. In both cases, the teachers were beginning teachers. The first teacher was a middle school science teacher and the second teacher taught high school chemistry. Although there were some similarities in the PPTs (classroom discipline and positive atmosphere), most were very different from one another. From this, we can infer that their classroom practices and the interactions with their students were very different from one another as well. Although teachers operate on a set of PPTs that are often consciously held, oftentimes a teacher may not be conscious of the reasons for their actions or aware of the practice theory that guides particular decisions, they may simply be habits or routines. Or they may claim to have a theory, but not activate that theory when making instructional decisions.

Many contextual elements influence a teacher's personal practice theories, including their personal beliefs. Many studies have examined beliefs held by teachers

and how they determine what goes on in the classroom (Battista, 1994; Cornett et al., 1990; Czerniak, Lumpe, & Haney, 1999; Jordan & Stanovich, 2003; Proper, Wideen, & Ivany, 1988; Rimm-Kaufman, Storm, Sawyer, Pianta, & LaParo, 2006). While researchers agreed that there is no common use of the term “belief” in educational research, (Tobin, Tippins, & Gallard, 1994) they also agreed that teacher beliefs relating to the teaching-learning process are key factors that influence practice. The *American Heritage Dictionary* (“American Heritage Dictionary of the English Language,”) defined belief as a “mental acceptance of and conviction in the truth, actuality, or validity of something.” All teachers, according to the *National Science Education Standards* (NSES) (National Research Council, 1996) have “implicit and explicit beliefs about science, learning and teaching” (p. 29) which would include their assessment practices. Tobin et al. (1994) claimed that those beliefs can impact practice by “determining whether particular actions are legitimate in the culture of the science classrooms in which they operate” (p.55).

Knowledge and understanding of science, and how to teach it are other contextual elements that affect PPTs. Both subject-matter knowledge and pedagogical knowledge are important. In addition, *pedagogical content knowledge* has been suggested as a third major component of teaching expertise (Shulman, 1986). Pedagogical content knowledge refers to an integration of content with pedagogy (Tobin et al., 1994). According to Hashweh, (1987) teacher pedagogical content knowledge includes a knowledge of the concepts, principles, and topics in a discipline, and the knowledge of how to teach a particular topic.

Shulman (1986) elaborated on forms of knowledge and contended that there are three forms of teacher knowledge: propositional, case or theoretical, and strategic knowledge. Propositional knowledge is based on research, personal experience, or moral reasoning that Shulman referred to as principles, maxims, and norms of teaching. Principles are based on research and can serve as useful guidelines when making educational decisions. Maxims are practical claims that represent the accumulated wisdom of practice or lore of teaching and “in many cases are as important a source of guidance for practice as the theory or empirical principles” (p.11).

Maxims appear to be the result of what Duschl (2007) referred to as “folk pedagogy” or popular belief systems about how students learn, i.e. their mental model of the learner, and what teachers can do that results in or enhances student learning and understanding. Folk pedagogy represents a teacher’s working notion of learning.

The third kind of propositions “reflect the norms, values, ideological or philosophical commitments of justice, fairness, equity, and the like, that we wish teachers and those learning to teach to incorporate and employ” (p.11). Teachers refer to norms of teaching when they make decisions because they are “morally or ethically right” (p.11).

Shulman described case or theoretical knowledge as knowledge, of specific, well documented and richly described events that are developed through a theoretical understanding of teaching and require analogical reasoning and reflection. Both propositional and theoretical knowledge are decontextualized and result in a single rule, which can be problematic when placed in conflict with one another.

Strategic knowledge “comes in to play as the teacher confronts particular situations or problems, whether theoretical, practical or moral where principles collide

and no simple solution is possible” (Shulman, 1986, p. 13). Strategic knowledge requires professional judgment - not only of *how*, but of *what* and *why* and goes beyond propositional or theoretical knowledge.

The NSES (1996) stated “teachers must have theoretical and practical knowledge and abilities about science, learning and science teaching” (p. 28). The importance of content knowledge and pedagogical content knowledge was highlighted with the release of national documents such as the *National Science Education Standards* (National Research Council, 1996) and the *Benchmarks for Science Literacy* (American Association for the Advancement of Science, 1993). These documents outlined for teachers what content they should understand and teach for each grade level, as well as recommendations for pedagogical approaches that enhance science learning, including classroom assessment strategies.

A recent research study (Fox-Turnbull, 2006) showed that when a teacher had a deep pedagogical content knowledge about technology education, it influenced his formative assessment practices during instruction. The teacher gave high quality feedback to the students and was able to ask higher-level questions, which in turn, increased their achievement. His knowledge clearly influenced his personal practice assessment theories.

Although it is difficult to determine exactly how PPTs are originally formed, Sanders and McCutcheon (1986) concluded that some of the factors that influence a teachers’ PPTs, besides classroom experience included pre-service preparation, experiences at home, as a student oneself, and interaction with peers. “Some theories of action that are used in teaching are probably acquired early in life and come to be deeply

embedded in the teacher's cognitive and behavioral repertoires simply through use" (p. 59). However, many PPTs are acquired on the job. The development of PPTs is ongoing and influenced by practice, the reflection of practice, dialogue with, advice from, and observation of other teachers, watching students and reflecting on their learning, and patterns of regularities of school life (Sanders & McCutcheon, 1986). Sanders and McCutcheon (1986) observed that teachers develop PPTs through practice-centered inquiry. Reflections on the success of the experience during inquiry may cause them to "revise, confirm, augment, or otherwise change those theories" (p.61).

Even though it is possible for teachers to change their PPTs, many researchers (Battista, 1994; Enyedy, Goldberg, & Welsh, 2005; Gregoire, 2003) have contended that educational change is slow. Well-meaning teachers may recognize reform ideas, but those ideas may be incompatible with their current belief systems. Even if they acknowledge the value of the reform efforts, they may have difficulty modifying the deeply held beliefs that have guided their practice in the past. Enyedy, et al. (2005) concluded that beliefs and belief systems are highly resistant to change and do not easily succumb to argument or reason. In fact, Battista, (1994) expressed alarm when noting that some teachers' beliefs caused them to implement inappropriate curriculum, while blocking their understanding and acceptance of the philosophy of reform.

### External Factors that Influence Practice

According to Sanders and McCutcheon (1986):

Teaching consequently occurs in contexts shaped by such powerful, interrelated factors as the teacher's personality and talents, other teachers' actions, the nature of learners, interpersonal relations, psychological factors and social norms, the building's layout, school policies, external factors, and others. Any of these

factors may significantly influence the consequences of any particular action taken by a teacher. (p. 53)

One of the most obvious external contextual elements that influences instruction is the emphasis that has been placed on accountability. Recent federal and state reform movements have resulted in an unprecedented increase in the pervasiveness of mandated, group-administered achievement testing at state and district levels (Linn, 2000). According to a survey published in *Education Week* (Olson, 2001, January 11), forty-nine states in 2001 had statewide academic standards for at least some subjects, fifty states tested how well students were learning, and twenty-seven held schools accountable for results, either by rating the performance of all schools or identifying low-performing ones.

Although the goals of federally mandated reform movements such as NCLB may be justified, the demand for and emphasis on accountability has ultimately led to unintended side effects. For example, assessment practices have suffered. According to Stiggins, (2004, p. 23) the “belief in the power of standardized testing has blinded public officials and school leaders to a completely different application of assessment – day-to-day classroom assessment – that has been shown to trigger remarkable gains in student achievement” (p. 23).

Standardized tests serve as indicators of learning and achievement, rather than for use in improving learning and achievement of individual students, which is one of the primary goals of NCLB. They are assessments *of* learning as opposed to assessment *for* learning. Black and Wiliam (2005) claimed “multiple demands for accountability at different levels of the system have resulted in multiple assessment systems, but these tend



to be focused on measuring the amount of learning that has taken place, providing little insight into how it might be improved” (p. 249).

In some cases, educators have attempted to use summative tests to improve learning, and on occasion have shown a small measure of success (Leahy, Lyon, Thompson, & Wiliam, 2005). However, the information gleaned from a summative test is difficult to use as assessment *for* learning for two reasons. First, summative tests monitor overall levels of achievement but do not necessarily diagnose specific weaknesses. Second, the information arrives too late to be useful, however it might be used to make “broad adjustments to curriculum, such as re-teaching or spending more time on a unit, or identifying teachers who appear to be especially successful at teaching particular units” (Leahy et al., 2005, p. 19).

If educators want to improve student achievement, they must re-direct their focus from an emphasis on assessment of learning via summative tests, to assessment *for* learning (Stiggins & Chappuis, 2006), also known as formative assessment. Leahy, et al. (2005) likened this change to a shift from quality control to quality assurance:

Traditional approaches to instruction and assessment involve teaching some given material, and then, at the end of teaching, working out who has and hasn't learned it – akin to a quality control approach to manufacturing. In contrast, assessment *for* learning involves adjusting teaching as needed while the learning is still taking place – a quality assurance approach. Quality assurance also involves a shift of attention from teaching to learning. The emphasis is on what the students are getting out of the process rather than on what teachers are putting into it, reminiscent of the old joke that schools are places where children go to watch teachers work. (p. 19)

The new culture of mandated tests has also led to a change in how some educators and textbook publishers think about and use the term *formative assessment*. It has been narrowed down and redefined by some to refer to “a system of more frequent summative

assessments administered at regular intervals (often quarterly) to determine which students have not yet met state standards – an early warning system, if you will” (Stiggins & Chappuis, 2006). This procedure is also known as *benchmarking*. Black and Wiliam (2005) pointed out that many educators use benchmarking tests as predictors but warned that these so-called formative assessments rarely have an impact on learning.

Benchmarking can also squander precious instructional time.

Another unintended negative side effect of mandated testing includes changes in how teachers actually teach. Many teachers spend more time focusing on and preparing students for the high-stakes exams, and less time on the content students should learn, due to the enormous pressure they are under to have their students pass. “Teachers may increase their attention to specific topics, shift instructional time to concentrate more on the subjects that are tested, devise exercises that mirror test formats and expectations, and work with their students on such test-taking skills as filling in the bubbles on multiple-choice questions” (Olson, 2001, January 11, par. 40). Olson argued that this measurement-driven instruction actually replaces high-quality instruction, and instead of raising scholastic achievement, they are raising students’ ability to take tests. Popham (2006) noted the dangers inherent in measurement-driven instructions stating that:

Pressured teachers, then, will most likely succumb in desperation to any sort of quick-fix score-raising techniques that offer the promise of AYP (Adequate Yearly Progress) success – even though some of those techniques, such as relentless test-prep drilling using practice items practically cloned from the state’s standardized exams, are educationally unsound. (p.83)

The emphasis placed on summative, high-stakes testing sends a contradictory message to the classroom teacher, often leaving them confused about their role in the classroom (Black & Wiliam, 1998a; Smith & Southerland, 2007). Although teachers may begin

with the fundamental belief that their goal is to help students gain a deep understanding of science, mandates imposed by policy makers may cause them to alter their beliefs and determine that their role as a teacher is to help students pass standardized tests, with the assumption that passing the test is indicative of “knowing.” Alternatively, they may feel a sense of resignation and succumb to the external pressures they feel to focus on testing, rather than learning. Ultimately:

The interest and investment in summative assessment has far outstripped formative assessment as layer upon layer of these tests have been used for classroom grading as well as local, state, national, and international testing for public accountability. The demands of No Child Left Behind have intensified the use and attention given to summative assessment because states are required to articulate their achievement standards and report annual evidence of the proportion of students meeting those standards. (Stiggins & Chappuis, 2005, p. 17)

This emphasis on summative assessment is detrimental to the learning process. “The final irony is that it is precisely the demand for accountability which has produced unprecedented pressure to improve education systems that is likely to be the biggest impediment to achieving that improvement” (Black & Wiliam, 2005, p. 260).

### Literature Summary

Research revealed that proper implementation of various formative assessment practices raised student achievement in a variety of settings and disciplines. Almost all of the research studies investigated a single facet of formative assessment and its effectiveness, such as self-assessment (Fontana & Fernandes, 1994; Schunk, 1996), frequent feedback (Whiting et al., 1995), frequent testing (Martinez & Martinez, 1992), comments-only feedback (Butler, 1988), embedded performance assessment (Meisels et al., 2003), and informed feedback (Fox-Turnbull, 2006). These studies investigated

mathematics, language arts, and technology. There are only a few studies that investigated the use of formative assessment in the science classroom. The Bergan study (1991), explored math and science gains in achievement when implementing a measurement and re-adjusting system. Frederickson and White's research (1997) investigated self and peer-assessment in an inquiry-based middle school science curricular unit. Cowie and Bell (1999) investigated the difference in planned and interactive formative assessment and Ruiz-Primo and Furtak (2004; 2007) studied the informal formative assessment practices of three science teachers while implementing a physical science curriculum on buoyancy.

Several studies (Black et al., 2002; Duschl & Gitomer, 1997; Passmore & Stewart, 2006; Treagust et al., 2001; William et al., 2004; Wilson & Sloane, 2000) examined the use and/or effectiveness of formative assessment by teachers who had been trained to implement it into their classrooms. The Black study followed 36 science, math and English teachers as they implemented formative assessment strategies in their respective classrooms after receiving training in the King's-Medway-Oxfordshire Formative Assessment project. Teacher behavior and student achievement were both investigated.

The Duschl study investigated the conversation assessment strategies of teachers who had been trained to use curriculum that purposefully embedded formative assessment feedback in the structure of their curriculum.

Passmore and Stewart purposefully embedded formative assessment into evolution curriculum and worked with teachers as they implemented the curriculum.

They used the results of the investigation to document its effectiveness and to redesign the curriculum for future use.

The Treagust study examined an 8<sup>th</sup> grade science teacher as she taught a unit on sound, after being actively involved in a Professional Development project that promoted embedded assessment. This teacher was chosen to be the subject of the study because she was considered an exemplary teacher who was proficient at implementing the strategies she learned in the training. Student achievement was not a part of the study.

William et al. trained a group of math and science teacher to use formative assessment practices. Teachers in the study were supported by the researchers to choose and implement formative assessment practices that suited their goals and personal preferences. Student achievement served as an indicator of success.

Wilson and Sloane's research reported achievement gains for students placed with teachers who had received professional development for implementing an embedded assessment program (the Science Education for Public Understanding Program – SEPUP) in their science curriculum.

Some of these studies suggested that teachers embraced the new strategies they learned and possibly altered their personal practice assessment theories, although this observation is merely an assumption since their PPATs were not explicitly examined. More research is needed to determine what PPATs influence the implementation of formative assessment, which is one of the foci of the current study. The research conducted thus far on personal practice theories suggested that they are difficult to change and are highly influenced by external contextual elements. One of the most notable contextual element that may serve as an impediment to the implementation of

new formative assessment practices is the emphasis that has been place on summative, high-stakes testing. There has been no research conducted to date that investigates the personal practice assessment theories of science teachers and how they are constrained or facilitated by internally constructed and externally imposed contextual elements, and how those PPATs influence assessment practices in a typical science classroom.

CHAPTER III  
METHODOLOGY

Research Questions

This collective instrumental case study employed a mixed method approach to investigate the formative assessment practices and personal practice assessment theories of three high school biology teachers and the effects of teachers' assessment practices and theories on student achievement and motivation in science learning. Three major questions guided the research. Related questions were pursued to enhance understanding regarding the major questions in the study.

- 1) What formative assessment practices do individual teachers use in the science classroom?
- 2) What personal practice assessment theories influence the implementation of formative assessment by individual science teachers?
  - a. What do individual teachers expect to achieve using specific formative assessment practices?
  - b. What contextual elements constrain or facilitate the use of formative assessment by individual science teachers?
- 3) To what extent does formative assessment affect student achievement and motivation in the typical science classroom?

### Research Setting

The study focused on three biology classrooms at a public high school in a west Texas suburban community. Although the community is relatively small, Martin High School (a pseudonym) draws many students from the surrounding area and had an approximate student population of 1450 at the time of this study as outlined in Table 3.1. The Texas Education Agency rated Martin High School as “Recognized” in a system that, under standard accountability procedures could be designated as Exemplary, Recognized, Academically Acceptable or Academically Unacceptable. Standardized test scores, dropout rates for grades 7 and 8 and school completion rates for grades 9 through 12 determined the ratings.

Martin High School classes were arranged in a block schedule. Each school day consisted of four 90 minute class periods and alternated between first, second, third and fourth period on one day and fifth, sixth, seventh and eighth period on the next day.

*Table 3.1. Demographic Information for Martin High School*

African American	4.4%	Economically disadvantaged	22.9%
Hispanic	23.4%	Bilingual/ESL education	1.0%
White	69.7%	Gifted and talented	5.9%
Native American	0.5%	Special education	8.2%
Asian/Pacific Islander	2.1%		
		Total enrollment	1450
		Number of classroom teachers	125

Martin Independent School District (MISD) science teachers were chosen for this study for several reasons. MISD had a long history of academic excellence and often scored at the top of school districts in the state on the science exit-level state administered tests. Because it is well documented that formative assessment practices have a positive impact on student achievement, I perceived that the teachers in this school system used



effective assessment practices related to my research. MISD frequently conducted district-wide benchmark (pre-instruction) and checkpoint (mid- or post-instruction) exams, and disaggregated relevant data to pinpoint problem areas and make necessary adjustments to improve student achievement, which is one of the features (albeit not always an effective one) of formative assessment. Teachers followed common curriculum maps that provided guidelines on content, sequence of instruction, and suggested periods for implementation. 9<sup>th</sup> - 12<sup>th</sup> grade science teachers at MISD developed the science departments' curriculum map in 2004, which were tweaked annually based on curriculum diaries kept by all the science teachers during the course of the year. (See Appendix A for a snapshot of an MISD biology diary curriculum map.) According to the building principal at MISD (personal communication, April 23, 2008), curriculum diaries were central to the drive to revise consensus map in a campus-wide effort to improve instruction. Also, teachers were strongly encouraged to spend time reflecting on the strengths and weaknesses of their teaching practices and make instructional adjustments accordingly.

In the academic year of this research, district-wide benchmark exams were administered in October to all biology students, which provided teachers with data for analysis of student achievement, and common checkpoint tests were administered periodically throughout the academic year. Because all teachers in the study, 1) received much of the same professional development provided by MISD, 2) taught students of comparable socioeconomic status, 3) had comparable teaching schedules and conference times, and 4) worked under the same administration and physical conditions, some of the confounding variables that impact student achievement and motivation were reduced.

However, one class in the study was an advanced biology I class and two classes were regular biology I classes, which enrolled one or two special education students. Except for the ability level of students, the uniformity of other factors made the study of three different biology teachers and their students suitable for comparison.

### Choosing Participants

In the fall of 2007, I gained written permission from the superintendent at MISD and the State University Institutional Review Board (IRB) (see Appendix B) to conduct the study. All 6<sup>th</sup> - 12<sup>th</sup> grade science teachers (n=24) at MISD were asked to complete a survey (Appendix C) that provided background biographical information and a self-report of their use of a variety of different formative assessment practices. Twenty-one of the 24 teachers returned a completed survey. Survey results were analyzed in an attempt to select participants at two ends of the spectrum of formative assessment use. At the beginning of the research study it was my intention to conduct an in-depth, comparative analysis of four teachers, two self-reported high frequency and two self-reported low frequency users of formative assessment practices within the same discipline (biology, chemistry, physics, or integrated physics and chemistry) and school district, in an attempt to isolate and illuminate factors that affected their assessment decisions and to compare student achievement and motivation. However, results from the initial survey revealed that although teachers reported using different types of practices, differences in degree or level of formative assessment use were negligible between teachers within the same discipline. Therefore, three biology teachers were chosen for the study based on their self-reported formative assessment practices, classroom observations, their assignment to

teach biology, and their desire and willingness to participate in an extended research project. By confining the cases to teachers within the same discipline, I was able to explore differences in assessment practices during a common unit of study. Additionally, as a former biology teacher, I trusted that my experience and knowledge with regard to biology concepts and biology teaching would provide insight and a deeper understanding of classroom dynamics as teachers presented subject matter to their students.

Teachers selected for the study were contacted via email to arrange a meeting time to discuss research details. I met with each teacher individually and discussed the methods that would be employed to collect data including field notes, video recording, interviews, email correspondence, student achievement tests and motivation surveys. The three teachers selected for the study agreed to participate, and written consent forms (Appendix D) were obtained at the time of their individual meetings. Consent forms were also procured from the building principal (Appendix E) and from students and parents (Appendix F and G) prior to the beginning of the research. Teachers chose the following pseudonyms for the study: Phoebe, Mary and Monica.

#### Unit of Study - The Cell

The participating teachers and I determined that their instructional unit over prokaryotic and eukaryotic cells would be suitable for the purposes of this study. One biology class per teacher was chosen based on scheduling logistics. All three teachers used approximately 13 class periods to complete the unit, but in different time frames that ranged from January to April, 2008. Mary's class periods were 102 minutes long and a total of 22.1 hours of instruction was observed. Monica's class periods were 87 minutes

long and a total of 18.85 hours of instruction was observed, and Phoebe's class periods were 86 minutes long and a total of 18.63 hours of instruction was observed.

The cell unit taught by all three teachers addressed required content standards as specified in the Texas Essential Knowledge and Skills (TEKS) objectives as outlined in Table 3.2 below.

Table 3.2. *Texas Essential Knowledge and Skills Addressed in the Cell Unit*

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(4) Science concepts. The student knows that cells are the basic structures of all living things and have specialized parts that perform specific functions, and that viruses are different from cells and have different properties and functions. The student is expected to:

(A) identify the parts of prokaryotic and eukaryotic cells;

(B) investigate and identify cellular processes including homeostasis, permeability, energy production, transportation of molecules, disposal of wastes, function of cellular parts, and synthesis of new molecules;

(9) Science concepts. The student knows metabolic processes and energy transfers that occur in living organisms. The student is expected to:

(B) compare the energy flow in photosynthesis to the energy flow in cellular respiration;

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Each teacher's instruction outlined similarities and differences between prokaryotic and eukaryotic cells and between plant and animal cells. They placed particular emphasis on the structure and function of cell organelles, the role of the plasma membrane in diffusion and osmosis, and cellular energy concepts including photosynthesis and cellular respiration. Teachers also addressed several process skills as outlined in the TEKS that fostered students' abilities to conduct scientific investigations and understand the nature of science.

Teachers at MISD were required to teach the biology standards as outlined in the TEKS, follow a curriculum map that suggested the sequence and duration of instruction, and use a common textbook. However, the teachers had much autonomy in their selection of instructional strategies and approaches.

### Research Methods

This research study relied on a collective instrumental case study and cross-case analysis to examine in depth the formative assessment practices of individual science teachers and the personal practices assessment theories that influenced their instructional decisions. This study also used quantitative measures to measure student achievement and motivation.

According to Stake (2000), an instrumental case study is used to examine an issue or redraw a generalization. "The case is of secondary interest, it plays a supportive role, and it facilitates our understanding of something else. The case still is looked at in depth, its contexts scrutinized, its ordinary activities detailed, but all because this helps the

researcher to pursue the external interest” (p. 437). When several instrumental cases are studied together, it is considered a collective case study.

A mixed method approach in this research study was used because of the nature of the research questions. Some questions focused on classroom assessment practices in context, which could not be analyzed using quantitative methods, but could be examined within an instrumental case study. However, some questions sought a causal explanation, which required quantitative methods of collecting and interpreting data. Other quantitative methods were used to determine the validity of survey documents and the checkpoint test, and analyze the interaction coding system used to study communication patterns of teachers and students.

### Qualitative Methods

According to Glesne (2006), there are several ways to augment the trustworthiness of qualitative research through prolonged engagement, triangulation, peer review, member checking, thick descriptions and external audits. The following sections describe the qualitative procedures used throughout the study. For example, extended classroom observations were carried out to develop profiles of the participating teachers, which described in detail the degree, type, and frequency of their formative assessment practices, and were member checked for accuracy. To triangulate the data, a dialogue interaction analysis coding system was developed and employed to analyze communication patterns between students and teachers. Classroom communication patterns contributed valuable information in the development and analysis of their profiles.

Teachers' personal practice assessment theories were identified through semi-structured interviews, and triangulated with observations and field notes, surveys, artifacts, and member checking. Semi-structured interviews, brief conversations immediately before or after class, and email communications with the participants disclosed the intent of various assessment practices enacted by the participants, and contextual elements that influenced their PPATs. An administrator interview also provided insight into the purpose and success of programs implemented by the school district in an effort to facilitate formative assessment practices of classroom teachers at Martin High School. Throughout the study, a colleague served as an external auditor and examined my research process and products by auditing field notes, coding schemes, and other relevant documents.

### Classroom Observations

To learn more about the teachers and the context in which they taught I used ethnographic field methods and played the role of observer-as-participant (Glesne, 2006). During the study, thirteen class periods were observed and videotaped for each teacher. Thus, a total of 60 hours of instructional time was observed and recorded. (Due to scheduling conflicts, a colleague attended and taped five classes or 7.5 hours in my stead.) During classroom observations, extensive field notes were taken. Particular attention was paid to the formative assessment practices of the teacher, and teacher-student and student-student interactions. Personal reflections about learning events, student grouping, physical arrangement of the room and desks, the context of the lesson, activities, assessment opportunities, and classroom discourse between teachers and

students were recorded for each class. Teacher and student talk in the whole-class setting was documented using an Interaction Analysis coding system that provided a visual and numerical representation of classroom discourse. Artifacts including worksheets, lab instructions, assignments, and tests were collected daily.

### Interaction Analysis Code

The original Flanders Interaction Analysis (FIA) system, which was used in a modified form in this study, was developed in the 1960's to help teachers and other educators understand and improve teacher behavior in the classroom (Amidon & Flanders, 1967). The FIA system used ten numerical codes to classify teacher and student talk and interactions during instruction.

Using the original FIA system as a model, a new interaction analysis coding system was developed to capture and classify important features of communication that occur in a learner-centered classroom. (See Appendix H.) Communication patterns found in learner-centered classroom and highlighted in Table 3.3 were used to develop the learner-centered interaction analysis (LCIA) categories.

The original interaction code developed at the beginning of the study was detailed and comprehensive, with 30 possible teacher and student dialogue patterns. (See Appendix I for the original code.) Every whole-class conversation including lectures, test reviews, pre- and post-lab discussions, student presentations and any other talk between teachers and students that involved learning, was coded for the duration of the research period. During the coding sessions, a number was recorded approximately every three seconds (or less during rapid fire question and answer sequences) that represented the



category of communication occurring at that time. Using the patterns that emerged using the original code, a condensed code was developed to use for further data analysis and reporting purposes. See Table 3.4 for the coding categories of the Learner-Centered Interaction Analysis (LCAI) system and Appendix H for a complete description of category guidelines.

Table 3.3. *Communication Patterns used to Develop the LCIA Categories*

<b>Discourse patterns consistent with the implementation of formative assessment in a learner centered classroom</b>	<b>Discourse patterns inconsistent with the implementation of formative assessment in a learner centered classroom</b>
Students' current understandings inform the planning and conduct of class sessions	The teacher lectures without seeking to reveal students' current level of understanding and, as a result, the probability that the instruction may be inappropriate increases
The teacher integrates students' ideas and comments into the classroom discourse	The teacher does not incorporate the ideas or comments of the student into classroom discourse
Student questions or comments influence the nature of classroom discourse	The teacher adheres to a set plan that tends to be subject-matter centered (May have been willing to change direction of instruction, but were unaware of student's lack of understanding)
There is a high proportion of student talk including sharing ideas and asking questions	The proportion of teacher talk to student talk is high
Questions posed by teacher are probing and divergent; the intent is to find out where students are in their understanding and to promote deeper thinking, striving for understanding. Helps develop student cognitive and metacognitive skills	Questions posed by teacher tend to require factual recall – i.e. terms and definitions or answers based on rote memorization. The teacher tends to seek and direct students toward a preconceived answer
Answers from the teacher are indirect (depending on the type of question) and carefully scaffolded to help the student build on existing knowledge	Answers from the teacher tend to be direct – they just tell the student the answer

Table 3.4. *Learner-Centered Classroom Interaction Analysis (LCIA) Categories*

Silence	<p><b>0. Silence, confusion or transition</b></p> <ul style="list-style-type: none"> <li>Pauses, short periods of silence, transition periods, laughter or confusion in which there is no communication or it cannot be understood by the observer</li> </ul>
Teacher talk	<p><b>1. Direct teacher talk</b></p> <ul style="list-style-type: none"> <li>Direct transmission of teacher ideas or knowledge from teacher to student through verbal and graphic means. Includes directions for assignments, activities or classroom management purposes</li> </ul>
	<p><b>2. Asks convergent questions</b></p> <ul style="list-style-type: none"> <li>Questions allow for a limited response</li> </ul>
	<p><b>3. Asks divergent questions</b></p> <ul style="list-style-type: none"> <li>Questions allow for a number of answers</li> </ul>
	<p><b>4. Learner centered talk</b></p> <ul style="list-style-type: none"> <li>Explicitly relates to or references prior learning experiences or knowledge</li> <li>Links content or explanations to existing knowledge</li> <li>Clarifies, extends, incorporates or builds on students' ideas or comments</li> <li>Asks students to respond to another student's answer, question or comment or to critique or extend their own answer or comment</li> <li>Answers a student question by helping them build on what they know</li> <li>Changes direction or content of talk in response to student question, comment or level of understanding</li> </ul>
	<p><b>5. Wait time</b></p> <ul style="list-style-type: none"> <li>Waits a minimum of 3 seconds before or after a student response or question</li> </ul>
Student talk	<p><b>6. Student talk – response</b></p> <ul style="list-style-type: none"> <li>Responds to teacher questions and directions (read the next paragraph; share the results you obtained, etc.)</li> </ul>
	<p><b>7. Student talk – initiation</b></p> <ul style="list-style-type: none"> <li>Initiates talk without a teacher prompt</li> <li>Shares experiences, voices ideas, makes comments or contributes to the search for meaning or understanding</li> <li>Asks questions</li> <li>Elaborates on another student's answer, question, comment or idea</li> <li>Answers another student's question</li> </ul>

Coding and data entry. During the classroom observation period, patterns were identified that represented typical instructional practices for each teacher. Some practices were common across all three classrooms and some were unique to each teacher. In an

effort to collect data that described or represented the student-teacher interactions during classroom conversations, specific instructional segments were chosen based on what was considered “typical” for each individual teacher. The segments were reviewed and analyzed via the DVD recording of the class.

A second coder was trained to code the segments of instruction to establish inter-rater reliability. Each coder used the LCIA categories to code selected instructional segments. Data from the two coders were analyzed and differences were resolved through subsequent reviews of problematic sequences, as suggested by Frankfort-Nachmias and Nachmias (1996). Frankfort-Nachmias and Nachmias cautioned, “Codiers are required to exercise more judgment in classifying responses when they are coding open-ended questions or other non-structured material” (p. 342) which has the potential to make the process unreliable. Therefore, they recommend that coding schemes be kept as simple as possible to avoid reliability issues. This recommendation was satisfied by using only eight, instead of 30 category items.

After coding and validating an instructional segment, a portion (100 tallies at 3 second intervals or less) of each teacher’s sequence of coding was graphed using Microsoft Excel to provide a visual representation of the classroom instructional segment. In determining which portion to graph, I conducted analysis of the entire recorded session, as reported in the matrix table, and chose a portion of the sequence that depicted typical interactions within the communication that took place. For example, if the matrix table revealed a high number of convergent questions followed by a student response, I chose a portion of the graph that illustrated convergent questions followed by student responses.

Code values were put in pairs for the purpose of analyzing patterns of student-teacher interactions. In the hypothetical sequence in Figure 3.1, pair one represents the teacher's direct talk followed by a teacher's divergent question. Pair two represents a teacher's divergent question followed by wait time, and so on.

*Figure 3.1:* Hypothetical dialogue sequence using the LCIA coding system.

Pair number	1	3	5	7	9	11	13	15	17
Pair	[1-3]	[5-5]	[6-6]	[4-1]	[1-5]	[6-5]	[6-1]	[1-3]	[6-6]
Code	1, 3, 5, 5, 6, 6, 4, 1, 1, 3, 6, 5, 6, 1, 1, 3, 6, 6, 6								
Pair	[3-5]	[5-6]	[6-4]	[1-1]	[3-6]	[5-6]	[1-1]	[3-6]	[6-6]
Pair number	2	4	6	8	10	12	14	16	18

Data on the pairs were entered into an 8 x 8 matrix in the following manner. The first number in the pair indicates the row and the second number in the pair indicates the column. A tally was placed in the appropriate cell for each pair. The hypothetical instructional sequence has been placed in the matrix in Figure 3.2. Once totals were placed in the matrix, patterns emerged that showed sequences and frequencies of classroom communication interactions.

*Figure 3.2:* Hypothetical LCIA code pair totals in an 8 x 8 matrix with data from Fig 3.1

Category	0	1	2	3	4	5	6	7
0								
1		2		2		1		
2								
3						1	2	
4		1						
5						1	2	
6		1			1	1	3	
7								

Data analysis procedure. The matrix provides a convenient device for analyzing the interactions that occurred during classroom interactions between teachers and students. Patterns are readily discernible and it is easy to note areas with many tallies and those with few or none.

Figure 3.3 highlights portions within the matrix that designate areas of teacher talk in the upper left-hand corner, and areas of student and teacher talk in the inverted L shaped area to the right and bottom of the matrix. A cursory glance at a completed matrix provides an overview of the balance of talk that occurred between teachers and students.

Figure 3.3. Blank matrix designating areas of teacher and student talk

	0	1	2	3	4	5	6	7
0	<b>Teacher talk</b>						<b>Student talk and teacher student interactions</b>	
1								
2								
3								
4	<b>Learner centered teacher-talk</b>							
5								
6								
7								
Total								
%								

Data in the matrix were used to calculate measures that reflected steady states and transitional states of the ratio of teacher and student talk, the ratio of teacher direct talk to learner-centered talk, the ratio of the convergent to divergent questions, and significant steady state cells and transitions from one category to another. The calculation of these measures is summarized in Table 3.5 and each measure is described in more detail below.

Table 3.5: *Measures for Analyzing Patterns of Interaction*

Item for analysis	Symbol	Formula	LCC	TCC
% Teacher talk	TT	$\sum(\text{Cat.1}+2+3+4) / \text{total tallies}$	↓	↑
% Student talk	ST	$\sum (\text{Cat 6}+7) / \text{total tallies}$	↑	↓
TT to ST ratio	TT/ST	%TT / %ST	↓	↑
Direct teacher talk to Learner-centered talk ratio	DTT/ LCTT	% Cat. 1 / % Cat. 4	↓	↑
Convergent to divergent questions ratio	CQ/DQ	% Cat. 2 / % Cat. 3	↓	↑
Significant steady state cells	SSC	[1-1] [2-2] [3-3] etc cells above 3% total tallies		
Significant transitional cells	STC	Any other cells (besides SSC) above 3% total tallies		

\*LCC – Learner centered classroom                      TCC – Teacher centered classroom

*Percentage teacher talk, student talk and TT/ST ratio.* This ratio represents the proportion of the total amount of interaction time taken up by the teachers, and by students. “Flanders argues that established norms are 80% teacher talk and 20% student talk” (Newman, 2001) which is a 4 to 1 ratio. However, in a learner-centered classroom, the percentage of student talk would be expected to be larger. A lower ratio between the two could be evidence of a more learner-centered classroom.

*Direct teacher talk to learner-centered teacher talk and ratio.* This ratio represents the proportion of teacher talk that is direct instruction (category 1), compared to teacher talk that explicitly involves the learner and promotes thinking and learning (category 4). In a learner-centered classroom, direct teacher talk would be expected to decrease and learner-centered talk should increase. A lower ratio between the two would be expected in a learner-centered classroom.

*Convergent to divergent questions ratio.* This ratio represents the proportion of convergent to divergent questions asked by the teacher. According to research on questioning techniques of classroom teachers, approximately 77% of all questions asked are convergent, and 17% divergent, a 4.5 to 1 ratio (Wilén, 1991). A lower ratio between the two would be expected in a learner-centered classroom.

*Significant steady state cells.* Cells that lie along the diagonal of the matrix are steady state cells ([1-1] [2-2] [3-3] and so on). Only when the behavior remains in a single category for longer than three seconds will there be tallies in these cells. If for example, there is a tally in the [1-1] cell, it means there was direct teacher talk for a sustained amount of time. These are the only cells in the matrix that identify continuous behavior in a category. The minimum cell value used for analysis in this category is 3%, which can be found by multiplying the total number of tallies by .03. Only the cells above the minimum value were considered significant. A learner-centered classroom would be expected to see a higher number of steady state cells in cells [3-3], [4-4] [6,6] and [7-7].

*Significant transitional cells.* All other cells in the matrix besides the steady state cells are transitional cells that represent movement from one category to another. Minimum value for analysis in this category is also 3%. Only the cells above the minimum value were considered significant.

### Teacher Interviews

Brief, frequent conversations were held with each teacher before or after class and focused on particular assessment activities they used during class that day, or on the

previous day. Questions addressed the purpose and perceived success of the assessment activities. Email communication also served as sources of information. In the email communications, teachers were asked questions such as: What was your purpose for implementing (a particular strategy)? Was your goal accomplished? How do you know? Did results of the activity lead to any instructional changes? If so, how? Answers were analyzed to reveal patterns that reflected the goals and intentions of teachers for the assessment practices they used. The information gained from these interviews was useful in addressing research questions about the purpose of their assessment practices, which influenced and are influenced by their personal practice assessment theories, and helped reveal the extent that student assessment results made an impact on future instructional decisions.

At the completion of the study, a 90-minute semi-structured interview was conducted with each teacher. See Appendix J for the structural outline that guided the questions in the interview. There were four primary aims of the interview: 1) to gain background information 2) to learn about their beliefs and understanding about teaching and learning, 3) to identify and discuss the teacher's personal practice assessment theories, and 4) to address the purpose and intent of specific assessment practices and the teacher's perception of its success.

After they provided pertinent biographical information, teachers were asked a series of pre-planned questions designed to identify contextual elements that influenced their personal practice assessment theories. Some important elements that previous research has identified included teachers' beliefs about how students learn, their level of satisfaction, their pedagogical content knowledge, their beliefs about their role as a



teacher in the classroom, organizational barriers including the emphasis on high-stakes tests, and social norms or assumptions about expectations of school administration.

These elements were directly or indirectly discussed during the interview. Although the interview included a set of pre-planned questions, follow-up questions varied depending on the response of the teacher.

Cornett's (1990) approach to accessing personal practice theories was used as a design model in this study. In the interview, the concept of "personal practice assessment theories" was explained to the teachers and they were asked to identify and/or describe their own personal theories about assessment. These theories were recorded and the teachers were asked to double-check them for accuracy. On the basis of an analysis of field observations, data from the original survey and from informal interviews, I inferred possible theories that appeared to guide their assessment practices. Teachers were asked to critically examine my summary of their PPATs to assess whether they conformed to their thinking and make any necessary changes, including elimination or modification of any inferred PPATs. Changes were made per teacher's instructions and the two lists were combined, categorized and prioritized (by the teacher) to reflect the PPATs they felt reflected their thinking and guided their teaching. Conflict arose as I analyzed their perceived personal practice assessment theories. Some theories they espoused were not evident in their practice, which led to additional analysis of the data collected in the study.

The interview also was used to identify what external contextual elements they felt constrained or facilitated their use of formative assessment practices. DVD clips of their use of specific practices were used to prompt their memory. They were asked

questions such as; Do you recall why you used this strategy? What were you trying to achieve? What did you learn about students? What did you learn about the value of the activity itself? Was it a good use of your time and that of the students'? Have you or would you use it again? Why or why not?

The high school principal was interviewed to gain more information about contextual elements that had the potential to constrain or facilitate the use of formative assessment practices by teachers in the school district. She was asked to describe district-wide efforts established to facilitate the use of formative assessment practices, the success or limitations of those efforts, and plans for future programs including professional development for the teachers. All interviews were tape recorded and transcribed for use during the data analysis process.

## Quantitative Methods

Quantitative components of the study include the development and analysis of the Formative Assessment survey, a student checkpoint test (Appendix K), a student motivation survey (Appendix L) and the analysis of dialogue interaction patterns derived from the interaction analysis coding system.

### Formative Assessment Survey

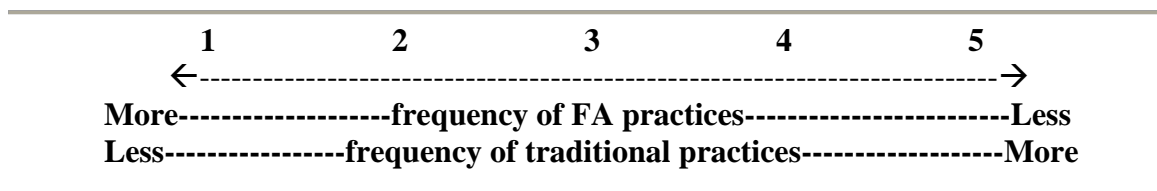
A Formative Assessment survey was developed and piloted in 2005 with a group of 22 local science teachers. Items in the survey inquired about their use of formative assessment practices identified through an extensive review of the literature. The survey included 32 statements, five of which were negatively stated with regard to formative

assessment practices and reversed during data analysis, and five were related to classroom practices not associated with formative assessment

After piloting the survey in 2005, statistical analysis was conducted to determine internal consistency estimates of reliability using Cronbach’s alpha and the survey was adjusted to improve internal consistency measures. The revised survey (Appendix C) was administered to all consenting MISD 6<sup>th</sup> - 12<sup>th</sup> grade science teachers at the beginning of the research study in the fall of 2007.

The survey used a Likert-type scale to rate teachers’ perceived frequency of use of a variety of formative assessment practices: 1 – often, 2 – frequently, 3 – sometimes, 4 – rarely, and 5 – never. The survey asked questions such as “I guide students to brainstorm and list student ideas on the board” and “I provide opportunities for students to reflect on their work.” Therefore, the lower the score, the more likely they perceived themselves to implement strategies consistent with formative assessment practices. See Figure 3.4.

*Figure 3.4.* Perceived formative assessment practices scale



The survey consisted of 32 statements and four free response items. Based on the reliability analysis, valid questions were identified and assigned categories based on the teachers’ self-reported classroom practices, including their 1) instructional response to classroom assessment, 2) classroom dialogue and questioning strategies, 3) written

feedback approach, and 4) efforts to involve students as partners in the learning and assessing process. Internal consistency estimates of reliability were computed for each survey category and expressed as Cronbach's alpha.

#### Category 1: Instructional Response to Classroom Assessment

These items assessed teacher perceptions about their degree of responsiveness to learner needs, abilities and level of understanding. Statements such as "I re-teach science concepts based on quiz or test results" and "I change my science lessons based on students' needs" were used.

#### Category 2: Classroom Dialogue and Questioning Strategies

These items assessed the teacher perceptions about their likelihood to elicit feedback that revealed students' current level of understanding of science concepts. Items were used to assess the degree of openness and freedom students had to express ideas, opinions and knowledge, and actively participate in the learning process. Items such as "I engage in extended dialogue with students to learn more about their thinking" and "I encourage students to voice opinions, ideas or knowledge about scientific principles" were used.

#### Category 3: Written Feedback

These items assessed teacher practices regarding grading and the type of feedback provided given to students. Items such as "I provide written feedback with advice on

improvement” and “I make written comments on returned papers instead of numerical grades” were used.

#### Category 4: Efforts to Involve Students in the Learning and Assessing Process

These items assessed whether teachers thought that they helped students develop a degree of ownership in their own learning and assessment. Items such as “I ask students to write out their learning goals” and “I provide a check-sheet or other document for self-assessment” were used.

Questions that required written responses were included to identify the teaching and assessing practices used, including the use and flexibility of lesson plans, the use of concept maps as instructional tools, and the purpose and usefulness of benchmark exams. In addition, teachers’ concepts of what constitutes successful instruction were sought.

Survey results were analyzed using descriptive statistics to identify the self-reported formative assessment practices of the Martin ISD high school and middle school science teachers. Free response items were categorized and coded and perceived practices and actual practices were analyzed in light of the personal practice assessment theories for the three biology teachers in the study.

#### Student Achievement

Achievement of students was measured through the administration of a checkpoint test covering cell concepts that had been emphasized during the unit. Multiple instructional resources (textbooks, study guides, and so on) were used as

references and appropriate questions were selected and modified to correspond to the six major topics addressed in the instructional unit: the structure and function of the cell and cell organelles, the role of the plasma membrane, the diffusion of water across the membrane under specific conditions, a comparison of prokaryotic and eukaryotic cells, and cellular energy including photosynthesis and cellular respiration. An additional section of questions was included that combined content knowledge about cellular energy within experimental design questions. Two colleagues with expertise in biology and science education audited potential test items and adjustments were made based on their feedback before administering the pilot test.

The original test consisted of 24 multiple-choice questions. For each topic, three levels (low, medium and high) of questions were developed. Low-level questions required memorization of facts or definitions of terms. Medium-level question typically called for students to apply their knowledge in answering the question, and high-level questions called for the synthesis of data to make predictions, draw conclusions and so on. Six additional questions required critical thinking and the analysis of a hypothetical experimental design involving cellular energy and plants.

The checkpoint test was piloted with a group of 50 biology students in comparable classes in a neighboring community and statistical analysis was conducted to determine internal consistency estimates of reliability using Cronbach's alpha. The alpha on the pilot test was .595. Items that exhibited low correlation values were adjusted or eliminated. Additionally, students who took the pilot test provided feedback regarding roots and/or answer choices that were confusing or contained strong contextual clues, which gave away the answer. Questions were edited as a result. Reading levels were

assessed using the Flesch-Kincaid Grade Level reading function in Microsoft Word. Alpha on the content test after editing was .746, an acceptable level.

Monica and Phoebe both administered the content test approximately six weeks after concluding their instructional unit on the cell. Mary's instruction on the cell was delayed and she did not complete her teaching unit until mid-April, negating the possibility of administering the test with six weeks between the conclusion of the unit and administration of the test. (Students would have been taking the checkpoint test after the state administered end-of-year test and therefore the results would have been of no assistance to Mary or to her students.) Therefore, Mary administered the test immediately following conclusion of her instruction. Due to the uncontrolled variable of time, Mary's student achievement scores were not used in further analysis.

To analyze achievement results, a one-way analysis of covariance (ANCOVA) was used. ANCOVA statistically controls for an extraneous variable, a covariate, by partitioning out the variation attributed to this additional variable. In this way, the researcher is better able to investigate the effects of the primary independent variable (Hinkle, Wiersma, & Jurs, 2003). A benchmark test that all biology students took at the beginning of the academic year served as the pre-test and the covariate to be factored out. The independent variable consisted of the two different treatment groups of Phoebe and Monica's students. The checkpoint test served as the dependent variable of ANCOVA. The scores (the dependent variable) of the two treatment groups on the checkpoint test were compared to assess the effect of instructional practices on student achievement while students' prior knowledge measured by the benchmark test was statistically controlled. Analysis was conducted on student scores on all seven subtopics and on the

three levels of difficulty. Based on my literature review, I anticipated that scores on the post-test for students who engaged in formative assessment practices more often would be higher than those who did not.

### Student Motivation

In order to assess the intrinsic motivation of students in this study, a survey was developed and piloted that contained two subscales: interest and perceived control. The subscale of interest was considered a self-report measure of intrinsic motivation and perceived choice or control was theorized to be a positive predictor of intrinsic motivation ("Self-determination theory: An approach to human motivation and personality," 2008). The survey used a Likert-type scale to measure students' intrinsic motivation and asked students to rate on a scale of 1 – 7 (strongly disagree to strongly agree) statements such as "I am very interested in learning biology" and "I have choices about how to learn biology concepts in this class." The original survey was piloted with a group of 50 biology students in comparable classes in a neighboring community and statistical analysis was conducted to determine internal consistency estimates of reliability using Cronbach's alpha. On the survey, four questions addressed interest and fourteen questions addressed perceived control. Of these eighteen questions, six were negatively stated and required reverse scaling before analysis. For interest and perceived control, the alphas on the pilot survey were .835 and .666 respectively. The interest subscale was satisfactory, so those items remained unchanged. The fourteen perceived control items were edited based in part on feedback from students in the pilot study.



Cronbach's alpha on the interest and perceived control on the final survey were .915 and .802 respectively.

A one-way multivariate analysis of variance (MANOVA) was conducted to determine the effect of the three teacher's classroom instruction and learning environment on the two dependent variables, students' interest and perceived control. Analyses of variances (ANOVA) on each dependent variable were conducted as follow-up tests to the MANOVA to assess whether there were differences among groups.

### Merging the Data

Field notes were used to determine how teachers and students spent their time during the research study. For example, class time was typically categorized into lecture, lab work, independent practice and other categories, depending on the teacher. Teacher assessment practices during the instruction of two specific sub-topics within the cell unit were examined in depth for all three teachers. The narrative describing those two sub-topics chronicled the sequence of their lessons and described attributes of formative assessment practices used during the lessons. The sub-topics selected for an in-depth analysis focused on cellular processes involving cell membrane permeability and molecular transport, and cellular energy. Although other sub-topics regarding the cell were emphasized in the unit, only these two topics were included in the summary narrative.

In the summary narrative, formative assessment practices were classified into three categories; 1) revealing strategies teachers used to make learning visible, 2) teachers' change in behavior in response to assessment-elicited evidence, and 3) the level

that teachers helped students take responsibility for their own learning and that of their peers.

Snapshots of particular events of interest provided a detailed description of the teaching and learning that took place and included segments of communication coded with the LCIA. Coded segments were graphed in order to provide a visual representation of the communication patterns that took place between the teachers and students and analysis of the interaction was provided. An overall summary was developed that revealed emerging patterns and outlined the teacher's use of formative assessment and the congruency of actual practice to their self-reported use of formative assessment.

Teachers' espoused theories about assessment were examined and compared to their actual practice. Discrepancies emerged, and, as a result, a distinction was drawn between espoused theories and actual theories in practice. Assessment theories in practice (PPATs) were analyzed in context of forms of knowledge as described by Shulman (1986) that informed and guided their assessment decisions, and contextual elements that influenced their instructional decisions and behavior.

Teachers' personal practice assessment theories were placed in context of the assessment development model (Figure 1.2) which provides a theoretical framework for understanding the dynamic interactions between PPATs, contextual elements and the implementation of formative assessment.

Teacher decisions and strategies related to formative assessment were rated using the rubric in Table 3.6 that described levels of performance on strategies that revealed student understanding, the teacher's level of responsiveness and their ability to help students take ownership of their learning.

Table 3.6. *Rubric to Determine Attributes of Formative Assessment*

Teacher actions that reflect attributes of formative assessment	← Higher Levels of Performance		
	3	2	1
Reveals students' current level of understanding, needs and abilities	Consistently uses a variety of strategies to probe for evidence of student understanding. Probes may be formal and purposely embedded or informal and "in-the-moment." Probes are characterized by a high level of effectiveness	Occasionally uses strategies to probe for evidence of student understanding. Effectiveness of these probes is mixed	Rarely uses strategies to probe for useful evidence related to student understanding. Strategies when used tend to be convergent questions
Responds to and builds on assessment-elicited evidence of students' level of understanding, needs and abilities	Uses assessment-elicited evidence about student understanding in an ongoing and regular manner that demonstrates responsiveness to student needs, builds on current understanding and adapts instruction as needed	Occasionally uses assessment-elicited evidence about student understanding in a manner that demonstrates responsiveness to student needs, builds on current understanding and adapts instruction as needed	Rarely recognizes or responds to students' understanding in an adaptive manner. May recognize and not adapt, or may not recognize and therefore not adapt instruction
Facilitates growth in the ability of students to take responsibility for their own learning and that of their peers	Consistently uses strategies that encourage students to become active partners (with each other and the teacher) in the teaching-learning process by providing assessment and learning opportunities designed to foster self-awareness, self-reliance and a community of learners	Occasionally uses strategies that encourage students to become active partners (with each other and the teacher) in the teaching/learning process by providing assessment and learning opportunities	Rarely uses strategies that encourage students to become active partners (with each other and the teacher) in the teaching/learning process by providing assessment and learning opportunities

A cross-case analysis was employed to synthesize data and reveal patterns within and across cases. This approach to analysis facilitates examining, identifying, and highlighting similarities and differences across and within cases with regard to formative assessment use and its impact on student achievement and motivation.

## CHAPTER IV

### RESULTS AND ANALYSIS

The first three segments of this chapter present individual findings from the case studies of the three teachers in this study. Analysis of the student content test, the student motivation survey and a cross-case analysis follows the individual case study results.

#### Phoebe – A Case Study

##### Background Information

Phoebe, a white female had 12 years of teaching experience at the time of the study. She had a Bachelor of Arts degree with a major in English and minor in biology, and was certified to teach both secondary English and biology in Texas. Upon gaining her undergraduate degree and teaching certificate, she taught middle school English for one year before being recruited to teach middle school science. She taught seventh grade science for one year and biology for one year at a magnet school before moving to MISD to teach biology. Phoebe was in her eighth year at MISD where she taught pre-AP (advanced placement) biology and was the head of the science department. She was in her last semester in a Multidisciplinary Science Master's Program and was scheduled to receive her Master's degree in the summer of 2008. The Master's program focused on improving content knowledge in biology, chemistry, earth science, physics and math while applying science concepts to the development of lessons appropriate for pre-college students.

I chose to study Phoebe and her students during her second period biology class. The class consisted of 17 ninth graders and one tenth grader. Three students were classified as gifted and talented and one as economically disadvantaged. There were no special education students in this class. Overall, Phoebe taught approximately 100 students during the semester observed. See Table 4.1 for demographic information regarding Phoebe’s students involved in this study.

Table 4.1: *Demographic Information of Phoebe’s Students*

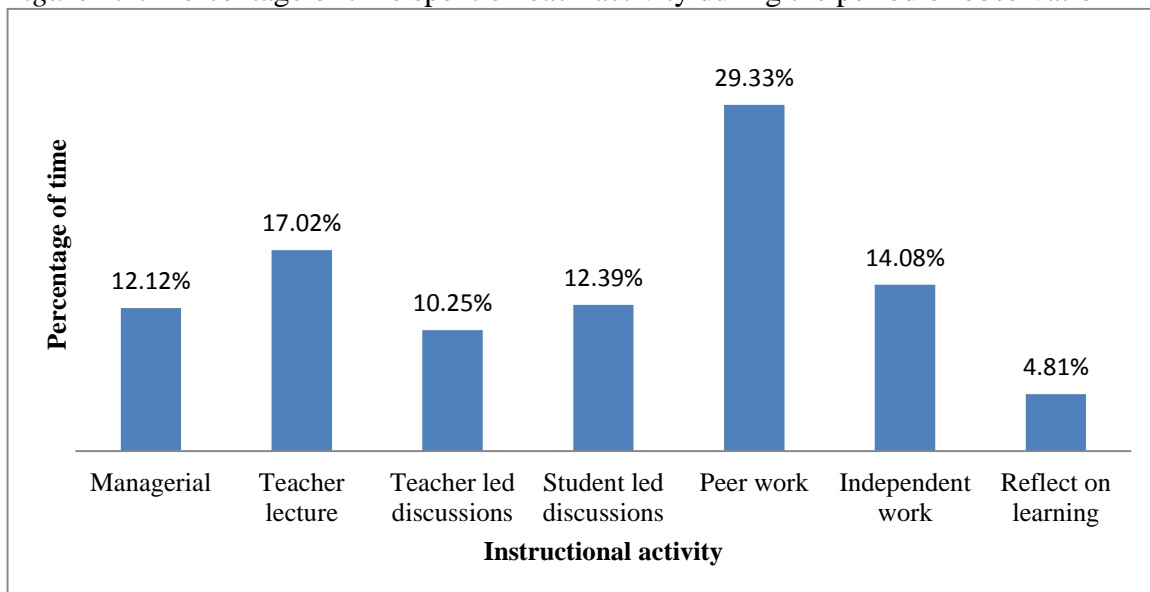
	<b>Female</b>		<b>Male</b>		<b>Both</b>	
	<b>N</b>	<b>Class %</b>	<b>N</b>	<b>Class %</b>	<b>N</b>	<b>Class %</b>
<b>White</b>	7	38.89	8	44.44	15	83.33
<b>Hispanic</b>	0	0	2	11.11	2	11.11
<b>African American</b>	0	0	0	0	0	0
<b>Asian/Pac.Islander</b>	0	0	1	5.56	1	5.56
<b>Other</b>	0	0	0	0	0	0
<b>Total</b>	7	38.89	11	61.11	18	

Phoebe’s biology room contained individual student desks that faced the dry-erase board at the front of the classroom. Her teacher desk was located off to one side at the front of the room. The back of the room held four large laboratory tables and science equipment was stored in cabinets around the periphery, providing ample room for storage of equipment and student investigations. She posted daily assignments on the large dry-erase board at the front of the room. Overarching themes in science and biology Texas Essential Knowledge and Skills objectives were posted around the room. She used the dry-erase board and a TV monitor connected to a computer to deliver notes via PowerPoint slides.

## Classroom Observations

Figure 4.1 shows the percentage of time Phoebe spent in each type of activity and provides an overall perspective of the instructional practices and patterns that characterized Phoebe's classroom during the six weeks and the 18.63 hours of observation completed for this study.

Figure 4.1. Percentage of time spent on each activity during the period of observation



### Categories

*Managerial* – This category included taking attendance, collecting and returning student papers, listening to announcements, and gathering and returning supplies by the teacher or students. Phoebe's students frequently prepared material that required using scissors, glue, index cards and other supplies. This category was coded for time spent gathering or returning those supplies, or getting organized, but not for the activity itself. Approximately 12% of their time was spent on organizational or managerial activities.

*Teacher lecture* – This category included instructional events wherein the teacher presented information to the whole class and students took notes. In Phoebe’s case, she presented lectures via a PowerPoint presentation displayed on a monitor at the front of the room. PowerPoint handouts served as an outline for students and they elaborated on the notes as needed. Of the total class time observed during this study, she lectured approximately 17% of the time.

*Teacher led discussions* – These activities, which occupied approximately 10% of the total class time included test reviews, “going over” homework and pre- and post-lab instructions and discussions in a whole-class setting.

*Student led discussions* – Student led discussions included planned instructional activities where students as individuals or in pairs shared their knowledge, understanding or ideas about particular science concepts in a whole-class setting. Notice that students led discussions approximately 12% of the time during this study.

*Peer work* – This category included any activity where students worked with a partner or partners for peer instruction, assessment, review, or to complete laboratory experiments, including the analysis and presentation of data. Most of Phoebe’s class time (29%) was spent with students working with a peer.

*Independent work* – Independent work included times when students worked individually to complete a learning task, such as taking a test or quiz, completing a worksheet, studying for a test, or preparing a foldable. Activities in this category occupied approximately 14% of the total class time.

*Reflect on learning* – This category included events where students were involved in self-assessment of their learning strengths and weaknesses, the assessment of the



teacher and her teaching practices, or in whole-class discussions about student learning and teacher practices. Notice that Phoebe's class spent approximately 5% of their time reflecting on the learning process.

#### Summary of Time Spent in Activities

Table 4.1 provided a summary of the percentage of time Phoebe and her students spent in a variety of instructional activities. Notice that students worked with a peer almost one-third of the time during this cell unit. Also note that students actively participated in the learning process. For example, Phoebe provided students the opportunity to share their knowledge, understanding and ideas with their peers through peer-led discussions, and to actively participate as they reflected on their learning and on Phoebe's teaching. Phoebe lectured and led whole-class discussions approximately one-fourth of the total class time and students worked individually on quizzes, tests or other individual tasks the remainder of the time.

#### Sequence of Lessons and Formative Assessment Use Summary

Table 4.2 provides a summary narrative that describes the sequence of instructional lessons and methods Phoebe employed for two sub-topics within the cell unit.

Table 4.2. *Summary Narrative for Two Subtopics in Phoebe’s Cell Unit Instruction*

<b>Cellular processes focusing on membrane permeability and molecular transport</b>	
<b>Description of Instructional Activity</b>	<b>Description and Category of Formative Assessment Attribute</b>
<p><u>Day 1:</u> To introduce the overarching theme of “form fits function” Phoebe provided pairs of students with a picture that represented a particular concept they had learned during the year. She asked them to think back and recall what they had learned about their assigned topic. After working in pairs for a time, she asked students to “stand and deliver” what they remembered about the concept. Throughout the discourse, Phoebe asked questions to help them conceptualize how form fits function in each example and then related the information to the form and function of a cell. <i>See Snapshots, Event 1</i></p>	<ul style="list-style-type: none"> <li>-Revealed student understanding about concepts (1)</li> <li>-Included explicit references to past learning experiences and built on existing knowledge (2)</li> <li>-Assessment-elicited evidence provided direction for instruction (2)</li> <li>-Provided students an opportunity for active engagement with a learning partner (3)</li> </ul>
<p>Brief PowerPoint presentation by Phoebe focused on the relationship between structure and function in a variety of cell types. Related new information to concepts learned earlier in the year about the characteristics of life including the role of the cell. PowerPoint slide handouts served as notes.</p>	<ul style="list-style-type: none"> <li>-Included explicit references to past learning experiences and built on existing knowledge (2)</li> </ul>
<p><u>Day 2:</u> Phoebe introduced the “Plasma Membrane Lab” to students, which was designed to investigate the role of the plasma membrane in regulating the diffusion of molecules into and out of the cell. The experiment used a chicken egg (reproductive cell) as a model cell. She asked a series of convergent and divergent questions and built on student answers to set the stage for learning about diffusion. Students worked in pairs to set up the lab.</p>	<ul style="list-style-type: none"> <li>-Probed and revealed students’ current level of understanding (1)</li> <li>-Built on student experiences and knowledge (2)</li> <li>-Provided students an opportunity for active engagement with a learning partner (3)</li> </ul>
<p><u>Day 3:</u> Students worked in pairs to collect data from their Plasma Membrane lab.</p>	<ul style="list-style-type: none"> <li>-Provided students an opportunity for active engagement with a learning partner (3)</li> </ul>

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Day 4: Students worked with their lab partner to analyze the data collected in the Plasma Membrane Lab. Phoebe circulated among the students and guided them to link evidence to explanations using phrases such as; “What do you mean by that? What do we know about...? How do you know that?” modeling critical thinking skills and processes. Important terms (diffusion, osmosis, homeostasis and so on) were introduced in context of the learning experience.

-Interaction with students provided opportunity to ‘see’ where they were in their learning (1)  
- Built on student experiences and knowledge (2)  
-Promoted student self and peer-reliance by requiring students to answer questions and draw conclusions based on the evidence provided by their data (3)  
-Aided in the development of metacognitive knowledge and strategies (3)

---

Day 5: Phoebe directed students to exchange and critique the lab report of a classmate other than their lab partner. Students shared the finding of their peers with the class. Data guided the direction of the discussion. Phoebe asked a series of convergent and divergent questions to help students connect evidence from their experiment to explanations about diffusion. *See Snapshots, Event 2*

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-Revealed student understanding about concepts (1)  
-Assessment-elicited evidence provided direction for instruction (2)  
- Built on student experiences and knowledge (2)  
-Promoted self and peer-reliance, trust and critical thinking skills (3)

Phoebe used the concepts students learned in the plasma membrane lab as a springboard for a brief lecture regarding the structure and function of the cell membrane. Provided formal definitions of key terms and other related concepts via a PowerPoint presentation. *See Snapshots, Event 3*

-Assessment-elicited evidence provided direction for instruction (2)

Phoebe provided students the opportunity to apply their knowledge about diffusion and the plasma membrane in a new context through a “Diffusion and Cell Size” lab. The purpose of the lab was to develop an understanding of how the surface area to volume ratio of a cell changes as the cell grows and how this ratio influences diffusion. Students worked in pairs to conduct the hands-on part of the lab activity.

-Built on what students had learned and applied concepts in a new context (2)  
-Provided students an opportunity for active engagement with a learning partner (3)

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Day 6: Continuation of the PowerPoint presentation from Day 5 provided further explanation of new terms and concepts related to diffusion and osmosis.

Students worked with their lab partners to analyze their data from the Diffusion and Cell Size lab. Phoebe circulated among students, answering questions and providing feedback and guidance, asking questions such as “What does your data say? What happened next? What does that tell us about rate?” modeling critical thinking skills and processes.

- Interaction with students provided the opportunity to ‘see’ where they were in their learning (1)
- Built on student experiences and knowledge (2)
- Promoted student self and peer-reliance by requiring students to answer questions and draw conclusions based on the evidence provided by their data (3)
- Aided in the development of metacognitive knowledge and strategies (3)

An optional homework assignment provided students the opportunity to relate cellular processes to medical conditions such as Cystic Fibrosis and others.

- Provided students the opportunity to take responsibility for their own learning and achievement (3)

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Day 7: Students worked independently to add teacher-prepared diffusion and osmosis graphics to their science journals.

Via a whole-class discussion, Phoebe asked students to incorporate evidence from the plasma membrane lab and the cell size and diffusion lab and from previous lecture notes to construct an understanding of the role of the plasma membrane in diffusion. Concepts were extended to include specific conditions of diffusion including hypo-, hyper- and isotonic solutions

- Built on student experiences and knowledge (2)

Students were unable to accurately answer questions during instruction regarding diffusion of water into cells in different conditions. In response, Phoebe depicted diagrammatically several different conditions on the board and asked student volunteers to come to the board, draw their predictions about the movement of water and justify

- Made learning visible (1)
- Assessment-elicited evidence provided direction for instruction (2)

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their answers. Classmates were asked to agree/disagree with a show of hands for each student presentation. Students that disagreed justified their position until a consensus resulted in the acceptance of a different conclusion or the initial conclusion.

Students worked with partners to finish Cell Size and Diffusion lab analysis and answer questions.

-Provided students an opportunity for active engagement with a learning partner (3)

Students were given two homework assignments. One required use of the textbook to answer direct questions about cellular transport and growth, and the second assignment directed students to design and carry out an experiment at home that applied new knowledge about surface area to volume ratio in an authentic setting.

-Built on what students had learned and applied concepts in a new context (2)

---

Day 8: Phoebe directed students to turn in homework and share how they designed and conducted their experiment. Discussion focused on what they learned about surface area to volume ratio and how it affected diffusion rate. This student/teacher interaction provided “teaching moments” that reinforced understanding and helped them prepare for the upcoming quiz.

-Revealed level of expertise with regard to processes of science and content knowledge (1)  
- Built on student experiences and knowledge (2)

Students studied independently and then in pairs for test

-Provided students an opportunity for active engagement with a learning partner (3)

Students took a 20 question, short answer test related to cell concepts addressed in the instructional unit. Questions ranged from factual recall, to synthesis and application of knowledge.

-Provided learning evidence to teacher and students (1)

Phoebe asked students to complete a Learning Questionnaire (Appendix M) and give her a “grade” on each assignment or activity related to instruction about the cell. Each activity or teaching strategy was listed and students were asked:

- Did you enjoy it? Do you even remember it?
- Did it help you understand the concept more?
- What changes would you make to the assignment?

-Feedback revealed information about student learning styles and the impact of teacher practices on learning (1)  
-Aided in the development of metacognitive knowledge and strategies (3)

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- Would you recommend that other students do the same assignment next year?
- Give Mrs. Phoebe an A, B, C or F

After the test, Phoebe led a whole-class discussion about what portions of the test they found difficult. Students joined Phoebe in coming up with ideas to help make sense of difficult questions.

-Aided in the development of metacognitive knowledge and strategies (3)  
 -Facilitated the growth of students as a partner in the learning process (3)

Day 9: Phoebe led a whole-class discussion about the Learning Questionnaire results and students provided additional input about conditions that facilitate their learning

-Aided in the development of metacognitive knowledge and strategies (3)  
 -Facilitated the growth of students as a partner in the learning process (3)

Phoebe returned graded tests to students and led a discussion about concepts that students found difficult. Directed students to complete a test analysis that included:

- summary of questions they answered right and wrong
- possible cause for any incorrect answers (classified as ‘simple mistake’ or ‘needs more study’)
- disclosure of how much time they spent studying for the test
- plan for improvement
- test corrections including an explanation of why their chosen answer was incorrect

-Test results and analysis revealed to the students and the teacher where they were in their learning (1)  
 -Aided in the development of metacognitive knowledge and strategies (3)  
 -Students role as a partner in the learning process is developed (3)

**Cellular energy including photosynthesis and cellular respiration**

**Description of Instructional Activity**

**Description and Category of Formative Assessment Attribute**

Day 10: Phoebe gave each student an index card with a question about a cellular energy concept. This pre-instruction assessment called “Quiz, Quiz, Trade” directed students to pair up and ask their partner the question on their index card. They traded partners and repeated the

-Revealed student understanding and provided evidence of knowledge (1)

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steps until every student was asked every question. Phoebe took a poll to find out what questions students were able to answer and what questions they were not able to answer. Index cards were sorted into “need to teach”, “need brief review”, and “no need to teach” categories.

Students prepared foldables with cellular energy graphics, terms and descriptions. Phoebe stated that she used this strategy in response to student feedback on the Learning Questionnaire.

-Assessment-elicited evidence provided direction for instruction (2)

Phoebe provided an optional homework assignment where students were expected to answer questions using information from selected internet sites, which reinforced their knowledge of cellular energy concepts.

-Provided students the opportunity to take responsibility for their own learning and achievement (3)

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Day 11: Phoebe’s starting point in the lesson on cellular energy was informed by the evidence from the pre-assessment from Day 1. She used brightly colored paper printed with relevant concepts to develop a concept map on the dry-erase board to help students learn the science and the importance of the key steps in photosynthesis. She explained her thinking along the way and justified the placement of each concept on the map. She asked convergent and divergent questions during the process to teach and to gauge student understanding. Students followed along and built the concept map in their journals.

-Interaction with students provided the opportunity to ‘see’ where they were in their learning (1)  
-Assessment-elicited evidence provided direction for instruction (2)  
-Aided in the development of metacognitive knowledge and strategies (3)

After this instruction, student pairs quizzed each other about photosynthesis.

Provided students an opportunity for active engagement with a learning partner (3)

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Day 12: Phoebe led a whole-class review to prepare students for a quiz related to photosynthesis.

Students work in pairs to review for the photosynthesis quiz.

Provided students an opportunity for active engagement with a learning partner (3)

---

Students were given a 15 question, short answer quiz that addressed new information learned about photosynthesis, and included questions from earlier lessons on cellular transport (based on previous test analysis evidence).

-Provided learning evidence to teacher and students (1)  
-Assessment-elicited evidence provided direction for instruction (2)

Phoebe used a PowerPoint presentation to describe cellular structures involved in energy production and explain how their structure was related to function

Included explicit references to past learning experiences and built on existing knowledge (2)

Phoebe began cellular respiration instruction by developing a concept map on the dry-erase board in a similar manner to Day 2. She asked convergent and divergent questions during the process to teach and to gauge student understanding. During the process, student copied the concept map in their journals.

- Interaction with students provided opportunity to 'see' where they were in their learning (1)  
-Assessment-elicited evidence provided direction for instruction (2)  
-Aided in the development of metacognitive knowledge and strategies (3)

At the end of class, students with questions about cellular respiration were given "one-minute cards" to record their questions and turn in before leaving class

-Made student level of understanding and interest visible (1)

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Day 13: Phoebe answered student questions from the one-minute cards collected the previous day.

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-Assessment-elicited evidence provided direction for instruction (2)

Continued to teach students about cellular respiration using the development of a concept map. She asked convergent and divergent questions during the process to teach and to gauge student understanding. Students copied the concept map in their journals.

- Interaction with students provided opportunity to 'see' where they were in their learning (1)  
-Assessment-elicited evidence provided direction for instruction (2)  
-Aided in the development of metacognitive knowledge and strategies

---



<p>At the end of the lesson, Phoebe conducted a post-instruction assessment with the same questions from the pre-instruction assessment (Quiz, Quiz, Trade game) through a whole-class question and answer session. Concepts were clarified or refined as necessary.</p>	<p>(3)</p> <p>-Revealed student understanding and provided evidence of learning (1)</p>
<p><u>Day 14:</u> Phoebe provided a verbal review over important concepts and then administered a 25 question multiple choice quiz covering cellular energy before moving on to the next important cellular process – mitosis (not a part of this study)</p>	

### Narrative Summary

The summary narrative in Table 4.2 describes a representative sample of Phoebe’s instruction that exemplified her approach to instruction and demonstrated the frequency and use of formative assessment practices. Notice that Phoebe began both topics with a planned formative assessment activity that revealed students’ level of understanding and provided evidence that was useful to make instructional decisions. Students were explicitly included as partners in the learning process as they openly shared their knowledge, understanding and ideas with their peers and with Phoebe. To facilitate learning about molecular transport in a cell, Phoebe provided a series of laboratory activities that developed the ideas and skills students needed. Concepts and terms were introduced in context, rather than as a set of isolated vocabulary words to be memorized. Students shared their findings with their peers in a setting that was supportive, emotionally safe and invited critical thinking and analysis. After students had the opportunity to explore and discuss concepts, Phoebe clarified and synthesized ideas through lecture. Her lecture was brief, well organized around big ideas and key concepts,

and built on their lab experiences. This learner-centered approach differs from traditional instruction where a teacher lectures first, then provides a confirmatory lab for students.

To apply what they had learned, Phoebe asked students to design and conduct an experiment that drew on their new knowledge about molecular transport. Their level of understanding was revealed as students described their findings in a whole-class setting.

Notice in the second sub-topic presented that Phoebe and her students spent time in metacognitive activities. Of particular interest is the Learning Questionnaire students completed on Day 8 (Appendix M). The purpose of the questionnaire was to gain feedback from the students about their learning styles and to assess the students' perceptions of the effectiveness of her lessons. This formative assessment activity provided benefits for Phoebe and for her students. She received useful feedback that she could use to alter instruction and involved students again as partners in the learning process.

Throughout the narrative notice that there was a balance of formative assessment practices used to reveal students' knowledge, understandings and ideas (Category 1), Phoebe's responsiveness to their needs, the frequent linking of new learning to students' existing knowledge (Category 2) and providing opportunities for students to take responsibility for their own learning and for that of their peers' (Category 3).

### Snapshots of Teaching Events

Specific communication events that occurred during the course of the unit warranted further analysis to help reveal the nature of teacher-student and student-student discourse that took place. The following events highlight patterns of communication and

the degree of learner- or teacher-centered discourse. A detailed description of each event is provided along with an Interaction Analysis coding sequence graph, matrix table and analysis of findings.

#### Event 1 – Day 1

On Phoebe’s first day of instruction of the cell unit, she began by allowing students to pick a partner for a “stand and deliver” activity. In this activity, she gave each pair of students a picture that represented a particular topic studied earlier in the year. She asked students to think about what they knew about the topic, stand up in front of the class, and share what they remembered. For instance, one group of students had a picture of plant roots they had learned about during an ecology unit studied in the fall semester. Phoebe called on the pair of students to stand-and-deliver. The following description provides a sample of the conversation that took place.

Student 1: We have taproots and fibrous roots. Taproots go, like, deeper in the ground for things that need water from like, further down and the fibrous roots spread out and they help anchor the plant.

Student 2: ...and they also cover more surface area so that when it rains they get more water.

Phoebe: Oh, very nice...they have a lot more surface area. So, cool, if you can cover a lot of surface area and get more water, why don’t all plants have fibrous roots?

Student 2: Because in some places it doesn't rain that much so they have to get their water from a deeper source inside the ground.

Phoebe: Ok, so you may find fibrous roots....do we find taproots and fibrous roots all the time in the same places?

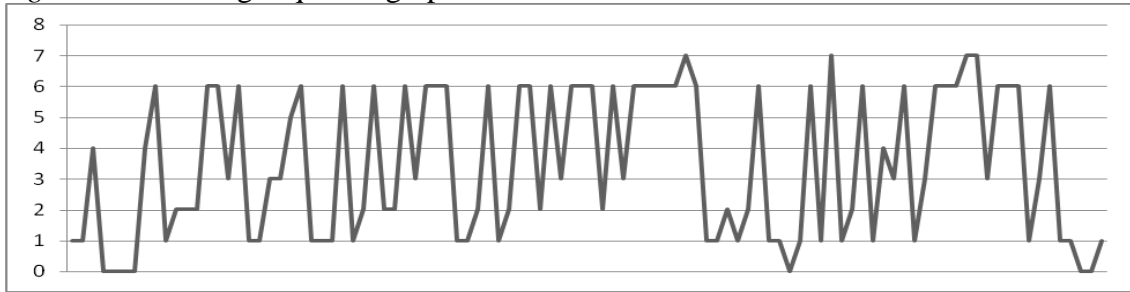
Student 1: No...they're different.

Notice that Phoebe asked divergent questions (why don't all plants have fibrous roots?) and convergent questions (do we find taproots and fibrous roots all the time in the same place?) during the exchange. Phoebe continued to ask convergent and divergent questions to guide students to the understanding that a common principle could be applied to the roots as well as all of the concepts students presented – one of the unifying themes in science, that “form fits function.” She referred to the examples that each group presented to help them conceptualize how structure and function are interrelated, and built on that knowledge as she applied the concept to the upcoming unit over the cell.

Figure 4.2 and Tables 4.3 and 4.4 present a coding sequence graph, an LCIA coding sequence matrix and an LCIA analysis table for Event 1. The graph represents 100 tallies (approximately five minutes), and the LCIA matrix and analysis provide detailed information for the eleven minute stand-and-deliver session.

Recall that in the LCIA, 0 = silence, 1 = direct teacher talk, 2 = convergent questions, 3 = divergent questions, 4 = learner-centered talk, 5 = wait time, 6 = student response and 7 = student initiated talk.

Figure 4.2. Coding sequence graph for Event 1



Notice the high frequency of interaction as depicted by movement from 1s, 2s, and 3s (teacher talk), to 6s (student response) that were sustained for long periods of time, and the occasional 7s (student initiated talk). In particular, notice that the communication is characterized by several divergent questions, followed by sustained student responses. The pattern of interaction depicted by the graph provides evidence that the purpose of the activity, which was to allow students to share existing knowledge about science concepts as prompted by the teacher, was achieved.

Table 4.3. *Interaction Analysis Coding Sequence Matrix for Event 1.* (Shaded areas represent significant steady state cells, and diagonal shaded areas represent significant transitional cells.)

	0	1	2	3	4	5	6	7	
0	4	3			1		1		
1	4	20	9	4	4		8	1	
2		1	4				17		
3			1	4		2	20		
4	1	1	1	4	9		2		
5							2		
6		24	7	15	3		35	3	
7		1		1			2	1	
Total	9	50	22	28	17	2	87	5	
%	4.09%	22.73%	10.00%	12.73%	7.73%	0.91%	39.55%	2.27%	
	Total							220	

Table 4.4. *Matrix Summary for Event 1*

Matrix ratios		Cell patterns
		<i>Significant Steady State cells</i>
%Teacher talk	53.18%	[1,1] Direct teacher talk
%Student talk	41.82%	[4,4] Learner centered to learner centered talk
		[6,6] Student response to student response
TT/ST ratio	1.272 to 1	<i>Significant Transitional cells</i>
DTT to LCTT	2.94 to 1	[1,2] Direct teacher talk to convergent question
Convergent to divergent questions ratio	0.79 to 1	[1,6] Direct teacher talk to student response
		[2,6] Convergent question to student response
		[3,6] Divergent question to student response
		[6,1] Student response to teacher direct talk
		[6,2] Student response to convergent question
		[6,3] Student response to divergent question

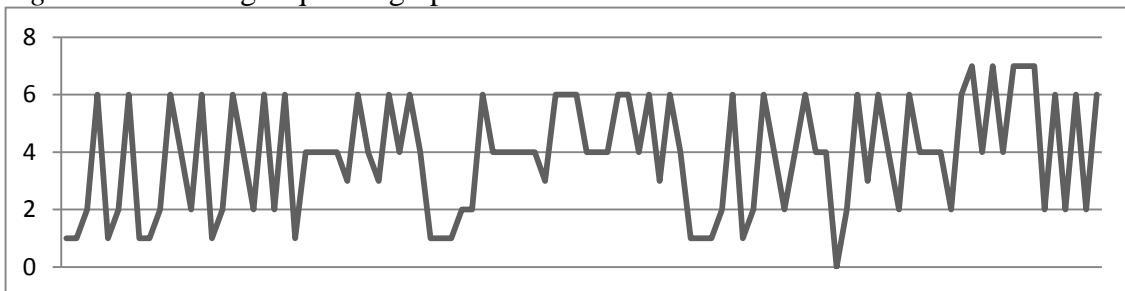
In this stand-and-deliver activity, students shared their knowledge as prompted by the teacher. Notice that almost all of the significant transitional cells contain a 6 (student response), indicating that students were very involved in the classroom dialogue. The steady state cell with the highest frequency was [6,6] signifying that students talked much more than average (Newman, 2001). This finding is consistent with the purpose of the activity - Phoebe wanted to assess their knowledge, therefore she used a strategy to reveal it. There is an approximate balance of teacher and student talk as Phoebe asked questions and built on their responses (another significant steady state cell [4,4]). She asked fewer convergent questions than divergent questions, which is atypical for classroom dialogue (Wilén, 1991), but not in classrooms where formative assessment is used. These divergent questions helped Phoebe “see” what her students remembered so that she could build her lesson appropriately.

## Event 2 – Day 5

Students had just worked with a partner to conduct an experiment that investigated diffusion and the role of the plasma membrane. They placed an egg in vinegar to dissolve the shell, then placed the shell-less egg in different solutions (corn syrup, vinegar or water) and monitored its change in mass over several days. At the end of the data collection period, they worked with their partner to analyze data and answer questions, using their results to draw conclusions about the movement of water across the cell membrane. Relevant science terms such as osmosis, dynamic equilibrium, and homeostasis were introduced at that time. Upon completion, students were asked to exchange lab reports with someone other than their original lab partner. Phoebe asked them to carefully read what their peer had written and make sense of their data. Then she asked a series of questions about their findings in a whole-class setting. Students were required to use the data from their peers' papers to answer the questions.

Figure 4.3 and Tables 4.5 and 4.6 present a coding sequence graph, an LCIA coding sequence matrix and an LCIA analysis table for Event 2. The graph represents 100 tallies (approximately five minutes), and the LCIA matrix and analysis table provide detailed information for the eight-minute post-lab discussion.

*Figure 4.3.* Coding sequence graph for Event 2



This graph depicts a high frequency of interaction between the teacher and the students. During this interaction, students were heavily involved in discussing the results of their laboratory activity. Many of Phoebe's responses were learner-centered (4s), as she referred to their findings and built on their understanding. Notice toward the end of the segment that students initiated talk, followed by a learner-centered response (4s) from Phoebe occurred. This could mean that students were asking questions, or sharing information or ideas.

Table 4.5. *Interaction Analysis Coding Sequence Matrix for Event 2*

	0	1	2	3	4	5	6	7
0			1					
1		6	10	1	1		1	
2			1	1	1	2	31	
3		1	1	4			10	1
4	1	2	11	6	16		4	2
5			1			2	1	
6		8	11	4	20		15	6
7			1	1	4			3
Total	1	17	37	17	42	4	62	12
%	0.52%	8.85%	19.27%	8.85%	21.88%	2.08%	32.29%	6.25%
	Total							192



Table 4.6. *Matrix Summary for Event 2*

<b>Matrix ratios</b>		<b>Cell patterns</b>
%Teacher talk	58.85%	<b><i>Significant Steady State cells</i></b>
%Student talk	38.54%	[1,1]Direct teacher talk
TT/ST ratio	1.527 to 1	[4,4] Learner centered to learner centered talk
DTT to LCTT	0.40 to 1	[6,6] Student response to student response
Convergent to divergent questions ratio	2.18 to 1	<b><i>Significant Transitional cells</i></b>
		[1,2] Direct teacher talk to convergent question
		[2,6] Convergent question to student response
		[3,6] Divergent question to student response
		[4,2] Learner centered talk to convergent question
		[4,3] Learner centered talk to divergent question
		[6,1] Student response to teacher direct talk
		[6,2] Student response to convergent question
		[6,4] Student response to learner centered talk
		[6,7] Student response to student initiates talk

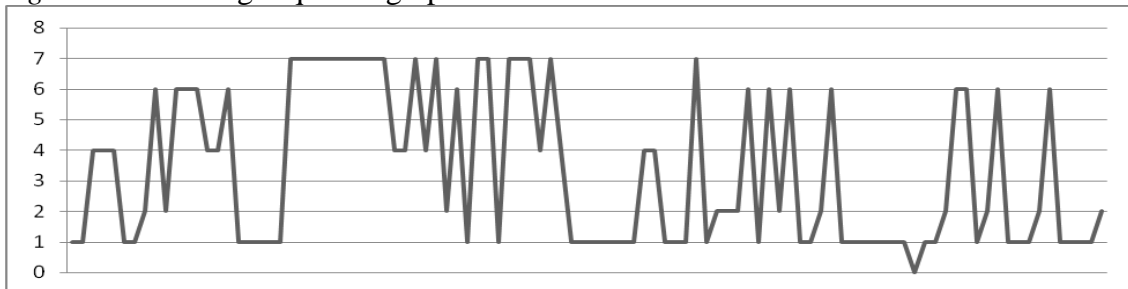
In the post-lab discussion, students were actively engaged in the conversation as each group discussed their lab findings and made sense of their data. Notice there were nine different significant transitional cells. The dialogue was highly interactive and diverse and included interactions between Phoebe and the students, and from student to student [6,7]. Because of the nature of the discourse, learner-centered talk occurred more than twice as much as direct teacher talk as she referred to their findings (notice the significant transition and steady state cells in the row and column of category 4). Convergent questions occurred twice as often as divergent questions but the ratio was still lower than average (Wilén, 1991). Convergent questions allowed Phoebe opportunities to guide students to conclusions about the activity based on their results.

### Event 3 – Day 5

After conducting and analyzing results from the plasma membrane experiment, Phoebe presented a lecture to formalize and clarify important terms and concepts. She provided students with a handout of her powerpoint presentation and lectured for approximately 20 minutes. During the lecture, she referred to the students' lab experiences and described the structure and function of the plasma membrane, fundamentals of general diffusion, and osmosis, the diffusion of water through a semi-permeable membrane. This synthesis of information set the stage for learning about special conditions of osmosis of water in hyper-, hypo-, and isotonic solutions. During this exchange, she used a series of convergent questions to consolidate what they had learned so far.

Figure 4.4 and Tables 4.7 and 4.8 present a coding sequence graph, an LCIA coding sequence matrix and an LCIA analysis table for Event 3. The graph represents 100 tallies (approximately five minutes), but the LCIA matrix and analysis table provide detailed information for the nine-minute introduction to diffusion portion of the lecture.

*Figure 4.4.* Coding sequence graph for event 3



This graph depicts a high frequency of interaction between Phoebe and her students, even during a lecture. In particular, notice the periods of sustained student

initiated talk where students contributed to the learning by sharing ideas or asking sustained questions. Also notice during this segment that there were more instances of teacher direct talk than in previous events, which is consistent with the nature of a lecture. Note that Phoebe posed very few questions, yet there were still many instances of student/teacher exchanges.

Table 4.7. *Interaction Analysis Coding Sequence Matrix for Event 3*

	0	1	2	3	4	5	6	7
0		1						
1	1	46	17	3	3		1	20
2			3				29	
3		1	1	2			2	
4		5	1		13		1	3
5								
6		22	8	1	1		10	3
7		8	1		7			14
Total	1	83	31	6	24	0	43	40
%	0.44%	36.40%	13.60%	2.63%	10.53%	0.00%	18.86%	17.54%
	Total							228

Table 4.8. *Matrix Summary for Event 3*

Matrix ratios		Cell patterns
% Teacher talk	63.16%	<b>Significant Steady State Cells</b>
% Student talk	36.40%	[1,1] Direct teacher talk to direct teacher talk
TT/ST ratio	1.735 to 1	[4,4] Learner centered to learner centered talk
DTT to LCTT	3.46 to 1	[6,6] Student response to student response
Convergent to divergent questions ratio	5.17 to 1	[7,7] Student initiated talk to student initiated talk
		<b>Significant Transitional Cells</b>
		[1,2] Direct teacher talk to convergent question
		[1,7] Direct teacher talk to student initiated talk
		[2,6] Convergent question to student response
		[6,1] Student response to direct teacher talk
		[6,2] Student response to convergent question
		[7,1] Student initiated talk to direct teacher talk
		[7,4] Student initiated talk to learner centered talk

As in previous events, teacher talk was less than average (Newman 2001), even though Phoebe was lecturing at the time. Notice the prevalence of significant transitional cells contain a 7 (student initiated talk) and that two of the four steady state cells were student talk [6,6] and [7,7]. At this point in the sequence of instruction, Phoebe was putting together everything they had learned thus far, and questions in her lecture were predominantly convergent rather than divergent (a 5 to 1 ratio).

### Summary and Significance of Emergent Patterns

The following narrative describes patterns that emerged in Phoebe's teaching related to formative assessment strategies that revealed what students knew, demonstrated her responsiveness to students' level of understanding, and demonstrated her efforts at activating students as partners in the learning process.

### Revealing Strategies

Throughout the unit, Phoebe used formal and informal formative assessment strategies to reveal student knowledge. Student-centered activities designed to reveal student understanding were commonplace, as evidenced in the stand-and-deliver activity. The stand-and-deliver strategy and the quiz-quiz-trade activity were both planned formative assessment strategies designed to elicit evidence of student learning and scaffold future knowledge. She consistently used convergent and divergent questions to involve the learner in classroom discussions to elicit information from them to gauge their understanding. The LCIA codes in most cases, showed that her ratio of convergent to divergent questioning was much less than in the average classroom (Wilensky, 1991).

As students worked with partners to analyze data, she continually circulated among the students, listened to their conversations, and stopped to converse with them when she recognized the need for redirection. At other times, students were at the board, revealing what they knew and contributing to the teaching/learning process.

Phoebe used frequent quizzes to ‘see’ where students were in their learning. Her quizzes were usually short answer, rather than multiple-choice, which provided insight into their degree of understanding. For example, on a cell test she administered after learning about the structure and function of cell organelles, she asked a mixture of questions of different levels of difficulty. Some called for low-level factual recall, and some required discussion of cellular phenomena based on a synthesis of their knowledge. For example she asked: 1) Why are cells small? (Use the following terms in your reasoning – diffusion, surface area, volume, nutrients and waste) and, 2) Enzymes are catalysts. What does this mean? What does it have to do with the amount of energy required for a reaction?

Additionally, she asked students to analyze their test results so that *they* could see where they were in their learning. In the Learning Questionnaire students provided information that revealed their preferred learning style and their opinion about the effectiveness of specific lessons she had used during the unit.

Her classroom practice was consistent with responses she made on her initial Formative Assessment survey. On the survey, her mean value for Category 2, Classroom Dialogue and Questioning Strategies, was 1.5, a strong use. On the survey, she stated that she often 1) used verbal questioning to determine students’ understanding of science concepts, 2) asked open-ended questions including *why* and *how* in whole-class

discussions, 3) encouraged students to elaborate on their answers in whole-class discussions and 4) asked students to voice opinions, ideas or knowledge about scientific principles and concepts. An overview of the LCIA coding graphs revealed a continual interaction between Phoebe and her students with instances of frequent student initiated talk. This pattern of interaction was consistent with the survey results.

### Responsiveness to Students

Phoebe was responsive to student needs, understandings, and abilities, which are defining characteristics of formative assessment. She used the evidence that she gathered during formal and informal revealing strategies to guide discussions and make instructional decisions. For example, after listening to student explanations during the stand-and-deliver activity, she was able to refer to their level of understanding as she wove their knowledge into a new context – the cell.

As students worked in pairs during data analysis, she was able to recognize problems they were having and was responsive to their needs. She redirected students by asking questions and prompted them to refine their thinking. During her lecture on day 7 about osmosis, responses by students provided evidence to Phoebe that they were having difficulty understanding what would happen to the cell under hyper-, hypo-, and isotonic conditions. She stopped the lecture and decided make drawings on the board that depicted the three conditions. She asked student volunteers to come to the board and illustrate predictions about the movement of water. They justified their prediction and classmates were asked to agree or disagree by a show of hands. Not only did this activity reveal where students were in their understanding, the evidence of student understanding

caused Phoebe to try a different approach to the presentation of material – the evidence guided her teaching.

When asked in an email about the plasma membrane lab, she stated that the lab had undergone several revisions over the years as she strove to improve it. She stated “In the past, I have done (this lab) *after* they received notes...but I think this will work out well because now they all have a common experience to pull from when we start to talk about hypertonic, hypotonic solutions and details about the function of the membrane.” Her actions and comments demonstrated that she had reflected on student learning in the past and adjusted her instruction to enhance the construction of knowledge.

The quiz-quiz-trade game was especially useful to Phoebe in providing evidence to direct her teaching about cellular energy. In a post-instruction email inquiring about the activity, she wrote:

I think the QQT was very influential in how I presented Photo/CR. Looking at my old notes, I would have spent some time – not a lot – but some VALUABLE time covering material the students had already mastered. (Insanity or what?) I think it was a valuable tool also to have before and after the lesson b/c it helped guide what I was going to teach as well as focus on what I was going to evaluate/test.

Phoebe was able to briefly remind students of the basics of cellular energy and spend more of her time instructing students about grade-appropriate concepts related to photosynthesis and cellular respiration.

She was also responsive to the opinions and ideas expressed by students on the Learning Questionnaire (Appendix M). For instance, many of the students reported that using foldables to organize their notes helped them learn. In response, on day 10, Phoebe shared with the students that, based on their responses on the Learning Questionnaire they would organize their cell energy notes in foldables.

On day 12, students still had questions about cellular respiration and Phoebe asked them to fill out “one-minute” cards. On day 13, she responded to their questions on the one-minute cards and spent the first part of the lecture addressing them. Clearly, their interest and understanding of the topic guided her instruction. She built on those questions as she moved on to the development of the concept map and further instruction about the cell.

Her classroom practice was consistent with responses she made on her initial Formative Assessment survey (rating a mean value of 2.5 in Category 1: Instructional Response). On the survey she stated that she frequently 1) changed the pace of her instruction based on student feedback, 2) collected student data and used it to determine what to teach next, 3) changed her lessons based on students’ needs, and 4) used assessment data to plan or adjust instruction. She also reported that she rarely adhered to her lesson plans.

### Responsibility of Students

Phoebe fostered a sense of community in her classroom and helped students take responsibility for their learning and for that of their peers. Students spent a great deal of time (29.33%) working collaboratively, either in conducting experiments, learning concepts together, quizzing each other in preparation for a test, or presenting their ideas. She promoted self- and peer-reliance by requiring students to depend on their data as they made discoveries and drew conclusions about cellular processes. At one point during the plasma membrane data analysis, she told the students “Don’t be afraid to think! And if you can back it up, write it down. Trust your data to help you make decisions.” She



frequently modeled critical thinking skills for students, a practice that helped them develop cognitive and metacognitive abilities. She would “think out loud” as she made connections during development of the concept map or during questioning students one-on-one during data analysis sessions. She also provided opportunities for students to develop their metacognitive skills when she had them analyze their test results and document questions that they answered correctly and incorrectly. She frequently led class discussions about their learning and helped them reflect on strategies they found effective. Phoebe helped students have a measure of control over their learning by providing optional homework assignments that enhanced their learning.

Although on the Formative Assessment survey, Phoebe’s mean value was 3.86 in Category 4: Involving Students in the Learning/Assessing Process, indicating that she rarely used strategies that fostered student responsibility such as guiding students to generate test questions, write out their learning goals, or involve students in developing rubrics, she fostered their development of self-reliance in other ways than those described in the survey.

#### Personal Practice Assessment Theories

Based on the interview with Phoebe at the end of the observation period, data gathered from observations, field notes, email correspondence, instructional artifacts and analysis of the data, two prevailing personal practice assessment theories (PPATs) that shape her formal and informal assessment decisions and practices were formulated. The following paragraphs describe her personal theories about assessment, evidence of

theories in practice, and types of knowledge that influenced the development of her theories and in turn, their importance in shaping her instructional decisions and strategies.

Personal Practice Assessment Theory 1: Student understanding is enhanced if they participate as partners with each other and with the teacher in the learning and assessment process.

Data from the various sources provided evidence that Phoebe was committed to the premise that students and teachers share the responsibility for student learning. This theory was reflected in her instructional decisions and strategies used throughout the observation period. At almost every opportunity, Phoebe involved students as partners with each other and as a partner with her as they learned scientific processes and concepts. Students rarely worked on a worksheet or assignment individually except for quizzes, tests and homework assignments. They taught each other, reviewed each other, critiqued each other's work, conducted and analyzed labs together, and as a whole class. Students frequently stood in front of their classmates and shared their knowledge, and other students elaborated or built on their peers' statements. It was commonplace for Phoebe to ask for a show of hands for students to express agreement or lack of agreement about ideas or problems, then the class would resolve issues together. She elicited and responded to their feedback about their own learning through the learning questionnaire and in frequent whole-class discussions. She gave them choices, such as optional homework assignments, designing their own labs, and designing a cell game to help them and their classmates learn. They had frequent discussions about their learning difficulties

and Phoebe listened to their concerns and adopted new strategies based on their input. In summary, they had choices and a voice as a partner in the learning process.

Theoretical knowledge served as the foundation for putting Phoebe's theory about assessment into practice. Her PPAT that student understanding is enhanced if they participate as partners with each other and with the teacher in the learning and assessment process goes against conventional folk pedagogy. Maxims or folk pedagogy in this regard might contend that when students work together, they are "cheating" rather than learning from each other. It may also hold that students may teach each other incorrectly, therefore it would be unwise to let them learn from each other, or that they do not have the knowledge or skills to critique each other, therefore it is the teacher's job. Additionally, because teachers are the "expert educators," and know how students learn, they should make all instructional decisions rather than seek student input. Keep in mind that there are levels of truth, or validity, to many maxims that undergird teaching practices, but they are not always grounded in theory.

Theoretical or case knowledge is developed through a theoretical understanding of teaching and requires reasoning and reflection according to Shulman (1986). Phoebe demonstrated a theoretical knowledge of the value of a community of learners as she connected with students and facilitated a partnership with and between students. Research (Bransford, et al., 2000) reported that a learning community where students share in the process facilitates the construction of knowledge and can optimize learning. Bransford, et al. (2000) contended that teachers must foster a sense of community among their students where they organize materials and activities in such a way that promotes intellectual camaraderie. In such a community "students might help one another solve

problems by building on each other's knowledge, asking questions to clarify explanations and suggesting avenues that would move the group toward its goal" (p. 25).

Personal practice assessment theory 2: Learning is optimized if the teacher assesses for understanding and adjusts instruction accordingly.

Data from various sources provided evidence that Phoebe was committed to this theory. Phoebe constantly probed student understanding through verbal questioning. Whether posed in a whole-class setting or to individuals, her questions were often divergent as she prompted students to reveal what they understood about scientific principles or concepts. The atmosphere in her classroom was open and inviting and students felt free to ask questions, share ideas or express confusion. The degree of openness allowed Phoebe to "see" what they knew and make instructional decisions based on what assessment-elicited evidence. Very little class time was spent reviewing low-level, factual recall material, although terms and concepts were consistently used in context as students constructed knowledge. For example, Phoebe introduced the concept of surface area earlier in the year to students as they investigated plant roots and water absorption during an ecology unit. It was applied again as Phoebe reinforced the concept of "form fits function" when describing the form of fibrous plant roots (high amount of surface area) and their function in absorbing water. The concept of surface area was addressed again as students investigated cellular growth and the significance of surface area to volume ratio. She developed students' ability to understand terminology and scientific concepts by applying terms in various contexts as opposed to memorizing them in isolation. In other words, she fostered an understanding of terms and concepts.

Therefore, during assessment, her goal was to determine their level of understanding rather than just their ability to memorize.

Several times during the study she changed her instruction based on assessment-elicited evidence. At times, the changes she made were unplanned and “in-the-moment” and at times she purposefully adjusted the sequence or emphasis of a lesson or activity based on evidence revealed during planned, formative assessment activities.

Theoretical knowledge and principles supported her theory about assessment and helped her put it into practice. Her PPAT that students’ learning was optimized if she checked for understanding and adjusted instruction accordingly was based on the principles of 1) the importance of teaching and therefore assessing for understanding rather than memorization and 2) the usefulness of formative assessment to determine students’ understanding. Wiggins and McTighe (2005) argued that, although all teachers claim to teach for understanding, evidence suggested that “to understand” and “to teach for understanding” are slippery terms (p. 35). Many teachers themselves simply do not grasp the meaning of *understanding* although they acknowledge the need to teach for understanding. For example, a maxim on science teaching might contend that “hands-on” activities develop understanding, when research shows that many activities can be hands-on, but not “minds-on.” Maxims may also claim that students can gain an understanding of a concept through repetitive drill and practice, or that if students understand, they can demonstrate their understanding on a paper and pencil test, or that knowing is equivalent to understanding. These propositions are based on folk pedagogy rather than on a theoretical foundation.

Bransford, et al. (2000) explained that understanding requires the ability to transfer knowledge and skills to a new context. The ability to know or remember is not the same as understanding. Phoebe's practice demonstrated that she taught for understanding. For instance, when teaching about how the ratio of surface area to volume changes as a cell grows, she had students design and conduct an experiment at home that applied concepts they had learned in class. Students transferred their knowledge to a context outside of the classroom. To assess their ability to transfer and use the knowledge, students shared their experimental design and results in a whole-class setting and Phoebe provided feedback throughout. This assessment also demonstrated the enactment of her first PPAT – that of students as partners in the learning and assessing process.

Her second PPAT, which claimed instruction should be adjusted based on assessment-elicited evidence, reflected her theoretical understanding of the usefulness of formative assessment to optimize student achievement. Assessment is not formative unless it “forms” what the teacher plans to do next (Black, 1998). Phoebe understood and showed that she could use assessment-elicited evidence to modify her teaching.

The enactment of both of Phoebe's PPATs (students as partners and assessing for understanding then adjusting instruction) demonstrated a theoretical knowledge of effective instruction enhanced through her ability to reflect on practice. Phoebe used practice-centered inquiry (PCI) to make instructional decisions. PCI, according to Sanders and McCutcheon (1986) occurs when teachers implement a new strategy or curriculum, reflect on the matter or seek out more information, and decide what to do in the future to improve or correct the situation. From the first day of observations during

this study, I heard conversations between Phoebe and the students about the success of various activities and reflections on how they could be more successful. For instance, on the first day, she shared with me that students were having difficulty learning terminology, so she wanted me to “bear with her” as they tried new strategies that she had learned in a workshop.

Throughout the course of the study, Phoebe shared her thoughts, goals, perceptions and frustrations in a reflective manner. She contended in her interview that she was never satisfied with her own teaching or with student achievement and sought to find better ways to teach and assess. For instance, although she taught for understanding and assessed accordingly most of the time, she still felt she could do a better job matching her learning goals with assessment strategies. As an example, she stated in an email that positive evidence of student learning from a Venn diagram activity prompted her to give students a pop quiz to see how well they had mastered the material. When asked to reflect about the activity she stated:

I’m also trying to make sure that I am assessing in a similar manner to how I am teaching. I struggle so much with assessment. Kids ALWAYS say my tests are too hard. My goal with tests is to make them apply their knowledge, but maybe I’m not providing them opportunities to do that in class, so I’m setting them up for failure.

Clearly, Phoebe wanted to move students beyond lower level thinking, which was reflected in her classroom practice, but she had difficulty knowing at times how to effectively match learning and assessment tasks in a practical, time-effective manner. She reported that she would prefer to conduct authentic assessments to determine students’ understanding, but sometimes reverted to paper and pencil summative tests because they were simpler to grade and objective rather than subjective. She recognized

the conflict and used her skills and theoretical knowledge to develop practice congruent with her theory. She continued to try new strategies, observe their effects, analyze them in context of her learning goals and make adjustments on an ongoing basis.

There is no distinct boundary between theoretical knowledge and strategic knowledge, as there are levels of each, but strategic knowledge ultimately moves beyond theoretical knowledge. Shulman (1986) claimed, “strategic knowledge must be generated to extend understanding beyond principle to the wisdom of practice” (p.13) and that strategic knowledge or judgment becomes necessary when principles are in conflict. For example, conventional wisdom may contend that “teaching to the test” is unavoidable in the current culture of high stakes testing where students at MISD had to pass the state mandated science exit-level test to graduate. However, Phoebe drew upon her theoretical knowledge of how students learn and the importance of teaching and assessing understanding to make educational decisions. Her wisdom of practice resulted in the merging of seemingly conflicted principles that was beneficial to the students and true to her personal theories of education. Her PPATs were informed by theoretical knowledge and reflected in her strategic knowledge.

#### Contextual Elements and PPATs

Several contextual elements had a direct impact on Phoebe’s PPATs and therefore the implementation of formative assessment in her classroom.



### Facilitating Contextual Elements

Factors that positively influenced Phoebe's PPATs and therefore facilitated her use of formative assessment included her mental model of how students learn, the autonomy that she maintained at MISD, relationships with her colleagues, and practice-centered inquiry.

### Mental Model of Learning

Phoebe's understanding of how students learned facilitated her use of formative assessment. She held a strong belief that students construct knowledge through experiences and that new concepts should be relevant to the learner and linked to something they know or have experienced. She expressed her mental model of how students learn as she imagined a spider web with many directions and interconnections and a variety of paths that lead to learning. She contended that it is the teacher's responsibility to scaffold lessons that build experiences and help students make proper connections. If left unattended, their spider web may lead them in a direction that does not fulfill, or achieve, the learning purpose. To effectively scaffold lessons, she needed to be aware of what knowledge and experiences students brought with them to the classroom. She stated "...as I get older, more experienced shall we say, I've had to take more of an interest in what they're supposed to come to me with so that I can help them make connections, because I don't think that they're making connections on their own." This mental model of how students learn made a positive impact on her assessment decisions – she strove to reveal prior knowledge as she strove to help students meet their learning goals.

### Autonomy

Phoebe had a great deal of freedom to make decisions about how she taught from day to day. She was encouraged to be creative and draw on her own experiences to provide opportunities for students in the manner she deemed appropriate. Her principal supported her practice as long as student achievement was optimum. Phoebe felt that she had a high level of autonomy but received help and support from her administration that enhanced her practice.

### Peer Relationships and Support

Phoebe also felt that she had a good relationship with colleagues at MISD and that they worked together as a team to help students be successful. They drew on each other's knowledge and experiences and frequently shared teaching ideas. She felt she was in an emotionally safe environment and that trial and error was a natural part of the process. She stated that in her experience at her prior school, she felt constrained to try new things because teachers were competitive rather than cooperative, but that at MISD, she was encouraged by other teachers and her mentor (her principal who had previously taught science) to explore new ways of teaching.

### Practice-Centered Inquiry

Phoebe's desire to be a better teacher also facilitated her ability to find, understand, embrace and implement formative assessment practices. She was never completely satisfied with her teaching or the student level of achievement and constantly strove to improve both. She said in her interview "I'm never, ever, ever, satisfied...you

know, I think that once you get comfortable, that's a dangerous place to be in education.” She continually reflected on the effectiveness of her lessons and tried new strategies to improve them. Additionally, she continued her education through a Master's program and took every opportunity to participate in professional development opportunities.

### Constraining Contextual Elements

Although Phoebe demonstrated a strong use of formative assessment practices, there were contextual elements that negatively affected her PPATs and constrained her use of formative assessment including student habits and dispositions, and state and local curricular requirements.

### Student's Response to High Stakes Tests

Phoebe did not appear to be strongly influenced by pressures that exist in an educational system in which the stakes are high to pass the end-of-year tests, however her students did. They apparently had a difficult time realizing that tests could be diagnostic rather than a final autopsy (her words). During tests, Phoebe circulated among students to help clarify questions as needed. She stated that she wished students would ask for help if they needed it. She did not want them to miss a question because they did not understand what it was asking. However, she felt that her students were too accustomed to the autopsy mentality and that the purpose of assessment was to judge their ability to answer the question on the test, not to see if they understood the concept. In an email correspondence, she stated, “I want them to learn to ask if they have questions. Apparently, in other classes the teachers tell the students that they cannot ask questions

on tests or quizzes. I don't understand that way of thinking/teaching." Students were accustomed to a culture of right and wrong, making the grade, and competition among students, rather than learning for its intrinsic value.

### Curricular Requirements

Another element that constrained Phoebe's effective use of formative assessment involved the pace she felt obligated to keep to teach the required state and local curriculum. This pressure sometimes caused her to be reactive rather than proactive in her planning and implementation of lessons and assessment. When discussing the difficulties involved with developing effective grading rubrics and lessons, she mentioned what she called a "front load philosophy." In other words, effective lessons require a lot of planning beforehand. She stated that:

...with these kids, we've got to give them more (learning) opportunities and it's going to take a lot of time. It would take me that time in the summer to frontload and develop those lessons and those opportunities and get it all together and probably take a couple of years to try it out...but it would take a lot of time in the beginning and I guess this is sometimes where I just feel inadequate as a teacher because I feel like I can't give it that much time.

### PPATs and the Assessment Development Model

The following narrative describes how the theoretical framework provided by the assessment development model (Figure 1.2) situates Phoebe's personal practice assessment theories into context. Two assessment theories guided Phoebe's practice. 1) Student understanding is enhanced if students participate as partners with each other and with the teacher in the learning and assessment process and 2) Learning is optimized if the teacher assesses for understanding and adjusts instruction accordingly. Many

contextual elements, both positive and negative influenced her PPATs and therefore the purpose, planning and implementation of assessment practices. Elements that facilitated her use of formative assessment included her beliefs about how students learn, the autonomy she experienced, the support she received, and practice-centered inquiry, whereas curricular requirements and the atmosphere generated by high stakes tests constrained Phoebe from fully implementing formative assessment practices.

These internally constructed and externally imposed contextual elements (F) and her PPATs (E) influenced her decisions about the purpose (A) of the assessment event. Phoebe used several different assessment methods with varied purposes, including the intent to 1) reveal what students knew, 2) share learning criteria with students 3) get feedback from her students about the effectiveness of lessons, 4) provide opportunities for students to monitor their own progress and 5) for accountability purposes. Therefore, as she planned (B) her assessment, she developed pre-instruction activities that probed for prior knowledge, rubrics that outlined grading criteria, a venue for students to provide feedback about instruction, quizzes and tests for formative as well as summative purposes, and test analysis forms for students to monitor their progress.

Assessment implementation (C) varied depending on the purpose of the assessment. To reveal and monitor student knowledge she used the quiz-quiz-trade or stand-and-deliver strategy, and short answer quizzes. To share learning criteria, she provided rubrics to students. She used the learning questionnaire to get feedback from her students and she implemented the student test analysis after returning their graded test and asked students to determine what areas still needed improvement. She also implemented a summative assessment for accountability purposes at the end of the entire

unit. As Phoebe reflected on her assessment activities (D) she shared that, 1) she needed to improve her rubrics so that they were more than a checklist, 2) she would continue to administer the learning questionnaire because it provided valuable information each year about her students, 3) the test analysis procedure needed work, because she was not sure how to help students master content from previous lessons once the group had moved on to new topics, and 4) she found the quiz-quiz-trade activity very effective. At the end of the unit, when she administered the questions again, she realized that she had not effectively addressed all the topics that she had intended to. The assessment item helped her see what students had learned, but it also helped her realize where her teaching fell short. This revelation caused her to alter her instructional plans for the future.

#### Formative Assessment Score

Phoebe's implementation of formative assessment practices during the cell unit was evaluated using the formative assessment performance rubric in Table 3.6. She consistently (3) used a variety of strategies to probe for evidence of student understanding. She began each sub-topic of her lesson with a planned formative assessment probe and continually used strategies throughout the lesson that revealed where students were in their learning. She sought feedback from the students to help her evaluate the effectiveness of her teaching strategies and their learning styles.

She was responsive to the assessment-elicited evidence about student learning in an ongoing manner (3) and continually built on what was revealed about their knowledge, skills, abilities and needs. She responded to their current level of understanding about the science concepts as well as the feedback that they provided regarding the effectiveness of

her lessons. Phoebe taught in a cycle of ongoing assessment, reflection, and adjustment to her lessons and teaching strategies.

She occasionally (2) used strategies that encouraged students to become active partners with her and with each other in the teaching/learning process. She frequently facilitated self- and peer-reliance building activities when possible. However, she could have been more effective in this area had she allowed students to help set learning criteria, create rubrics, set personal goals and monitor their own progress. She also missed the opportunity to help students see exactly what the learning goals were and where they were in relation to those goals. Phoebe's composite score for items on the formative assessment performance rubric was eight of nine, (accomplished).

### Mary – A Case Study

#### Background Information

At the time of the study, Mary, a white female, had 22 years of teaching experience and planned to retire at the end of the academic year. She had a Bachelor of Arts degree in Spanish with a minor in biology. Upon earning her B.A. she entered a post-baccalaureate program and became certified to teach Spanish and biology. Her initial plan was to teach Spanish, but upon graduation, she was offered a science position and subsequently taught biology for 21 years, with the exception of one year of teaching Spanish that occurred late in her career. During this study she was in her fifth year at MISD where she taught biology I and advanced placement biology classes.

I chose to study Mary and her students during her seventh period biology class. The class consisted of 16 ninth graders and 5 tenth graders. Two students were classified as special education students and eight as economically disadvantaged. Overall, Mary taught approximately 117 students during the semester observed. See Table 4.9 for demographic information regarding Mary's students involved in this study.

Table 4.9. *Demographic Information of Mary's Students*

	<b>Female</b>		<b>Male</b>		<b>Both</b>	
	<b>N</b>	<b>Class %</b>	<b>N</b>	<b>Class %</b>	<b>N</b>	<b>Class %</b>
<b>White</b>	10	47.62	5	23.81	15	71.43
<b>Hispanic</b>	4	19.05	1	4.76	5	23.81
<b>African American</b>	1	4.76	0	0	1	4.76
<b>Asian/Pac.Islander</b>	0	0	0	0	0	0
<b>Total</b>	15	71.43	6	28.57	21	

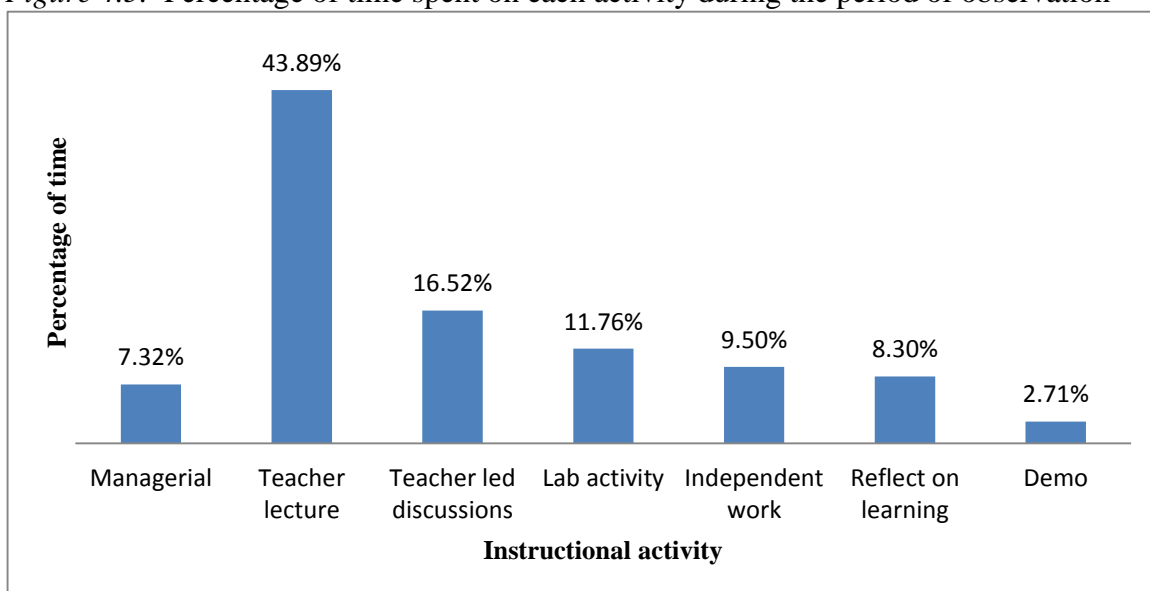
Mary's biology room contained individual student desks that faced the dry-erase board at the front of the classroom. Her teacher desk was located off to one side at the front of the room and four large laboratory tables were arranged at the back of the room. Science equipment was stored in a number of cabinets that surrounded the lab tables. She chronicled daily assignments on a large dry-erase board located near the student desks, and a bulletin board displayed the overarching themes in science. Mary used the large dry-erase board at the front of the room to write notes for students during lecture. The science lab and lecture area was large, and conducive to investigations and group-work by students.



## Classroom Observations

Figure 4.5 shows the percentage of time Mary spent in each type of activity and provides an overview of the instructional practices and patterns that characterized Mary's classroom during this period during the six weeks and 22.1 hours of observation completed for this study.

Figure 4.5. Percentage of time spent on each activity during the period of observation



### Categories

*Managerial* – This category included taking attendance, collecting and returning student papers, and listening to announcements. Approximately 7% of class time was spent on organizational or managerial activities.

*Teacher lecture* – This category included instructional events wherein the teacher presented information to the whole class and students took notes. Mary wrote or illustrated notes on the dry-erase board at the front of the room while she presented the

information. Students copied the notes and illustrations into their science notebooks. Most of Mary's class time (44%) was spent lecturing.

*Teacher led discussions* - These activities, which occupied approximately 16.5% of the total class time included test reviews, "going over" homework and pre- and post-lab instructions and discussions in a whole-class setting.

*Laboratory activities* – Activities coded in this category included instances when students worked individually or in pairs to answer questions that required the physical manipulation of science equipment or material. Students spent approximately 12% of their time in laboratory activities.

*Independent work* - Independent work included instances when students worked individually to complete a learning task, including taking a test or quiz, completing a worksheet, or studying for a test. Activities in this category occupied approximately 10% of the total class time.

*Reflect on learning* - This category included events wherein a student conducted a self-assessment of learning strengths and weaknesses, or Mary led a discussion about student learning. Mary's class spent approximately 8% of its time reflecting on the learning process.

*Demonstrations* – Activities coded in this category included instances when Mary demonstrated laboratory techniques and science phenomenon to the whole class as students observed and took notes. Demonstrations occupied approximately 3% of the total class time.

### Summary of Time Spent in Activities

Figure 4.5 provided a summary of the percentage of time Mary and her students spent in a variety of instructional activities. Notice that teacher-talk including lectures or teacher led discussions occupied approximately 60% of the total class time. Students spent 12% of their time conducting laboratory activities where they worked alone or in pairs, depending on the nature of the assignment. Absent from her classroom activities were opportunities for students to work with a partner in any other learning endeavor, besides the laboratory activities, nor did they spend much time working individually on learning tasks. However, it is interesting to note that they spent a good portion of time (8.3%) reflecting on their learning. The instructional approach depicted in Mary's class represents a teacher-centered rather than learner-centered approach to instruction.

### Sequence of Lessons and Formative Assessment Use Summary

Table 4.10 provides a narrative that describes the sequence of instructional lessons and the methods Mary employed for two sub-topics within the cell unit.

Table 4.10. Summary Narrative for Two Subtopics in Mary's Cell Unit Instruction

<b>Description of Instructional Activity</b>	<b>Description and Category of Formative Assessment Attribute</b>
<u>Day 1:</u> Mary opened the lesson on cellular processes with a lecture on the importance of form and function in cells followed by the history of the development of the microscope and the discovery of the cell. During the lecture, students frequently asked questions that drew on Mary's expert knowledge. As she lectured, she used the dry-erase board to draw illustrations and write down key concepts. Students were directed to copy the notes from the board into their science journals.	-Questions revealed student understanding and interest (1) -Responded to students' questions with knowledgeable feedback (2)

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Day 2: Mary continued the lesson on cellular processes with a lecture discussing the structure and function of the plasma membrane and how molecules move across the membrane during diffusion. *See Snapshots, Event 1.* During the lecture, students frequently asked questions that drew on Mary's expert knowledge. She spent time answering questions that diverged from the planned lessons, but were related to the instructional objectives. *See Snapshots, Event 2.* While lecturing, she used the dry-erase board to draw illustrations and write down key concepts. Students were directed to copy the notes from the board into their science journals.

-Questions revealed student understanding and interest (1)  
-Included explicit references to past learning experiences and built on existing knowledge (2)  
-Responded to students' questions with knowledgeable feedback (2)

Students were assigned a Plasma Membrane worksheet for homework.

Day 3: Mary returned graded homework (that was turned in to a substitute teacher when Mary was absent). She provided students with the correct answers, which they recorded on their paper as needed.

Continued the lesson on cellular processes with a lecture that applied what students knew about general diffusion to the diffusion of water in osmosis including hypo- hyper- and isotonic solutions. During the lecture, Mary introduced key vocabulary words and provided meaning to their individual prefixes, suffixes and root words. As she lectured, she used the dry-erase board to draw illustrations and write down key concepts. Students were directed to copy the notes as noted for previous classes.

Included explicit reference to prior learning experiences and built on existing knowledge (2)

Introduced the "Gummy Bear Diffusion" lab to students, which was designed to demonstrate permeability of a cell membrane and to distinguish between hypo- hyper- and isotonic solutions. Pre-lab instructions included a review of the formula and definition for the term "density".

Included explicit reference to prior learning experiences and built on existing knowledge (2)

Student pairs set up the Gummy Bear Diffusion lab.

Provided students an opportunity for active engagement with a learning partner (3)

Day 4: Mary provided instructions for students on how to collect data from their diffusion lab and reviewed necessary calculations and clarified key terms.

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Student pairs gathered data from their Gummy Bear Diffusion lab and completed questions on the lab handout. Mary circulated among students and answered questions as needed.

Promoted self and peer-reliance by requiring students to answer questions and draw conclusions based on the evidence provided by their data (3)

Post-lab discussion conducted by Mary explained and clarified the results of their experiment.

Included explicit reference to prior learning experiences and built on existing knowledge (2)

Day 5: Students took a plasma membrane and osmosis quiz that consisted of 12 fill in the blank responses (with a substitute teacher – Mary was on personal leave for the day)

Day 6: Mary returned the graded Gummy Bear Diffusion labs and discussed results with the students. She paid particular attention to items that many students missed.

Handed back the graded plasma membrane and osmosis quizzes. Students used their notes to make corrections and were awarded additional points for corrections.

Demonstrated osmosis in plant cells for students by using a flex-cam connected to a microscope and a monitor that enabled all students to see the reaction of plant cells when exposed to different concentrations of salt solutions. Students independently answered questions on a teacher-prepared handout. When all students were finished, Mary provided the correct answers and students graded their own papers.

Day 8: Mary continued the lesson on cellular processes with a lecture explaining how cell growth affects the volume to surface area ratio of a cell. As she lectured, she used the dry-erase board to draw illustrations and write down key concepts. Students were directed to copy the notes from the board into their science journals.

Gave students a worksheet that highlighted important concepts about diffusion. She provided the correct answers to students and they filled in the blanks. She used the opportunity to reinforce important concepts.

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Assigned homework “Surface Area to Volume Ratios for Cubes.” Discussed with students what patterns would emerge as they calculated the surface area to volume ratio of different sized cubes.

Day 9: (Substitute teacher gave students four worksheets to complete that focused on the plasma membrane and the transport of molecules.)

Day 10: Students studied individually in preparation for a test covering cell concepts.

Students worked individually to complete the cell test, which consisted of 50 multiple-choice questions.

Provided learning evidence to teacher and students (1)

Day 11: Mary returned graded tests to students and led a discussion about concepts that students found difficult as evidenced by their responses. She directed students to

- highlight questions they missed on their test
- write the correct answer on a separate sheet of paper
- explain why they think they missed it

-Test results and analysis revealed to students where they were in their learning (1)

-Aided in the development of metacognitive knowledge and strategies (3)

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**Cellular energy including photosynthesis and cellular respiration**

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**Description of Instructional Activity**

**Description and Category of Formative Assessment Attribute**

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Day 12: Mary introduced the concept of cellular energy with a lecture discussing the importance of energy production and key features of photosynthesis and cellular respiration. She related the information to what students had previously learned about the structure and function of the chloroplast. During the lecture, students frequently asked questions that drew on Mary’s expert knowledge. She drew illustrations and wrote down key concepts on the dry-erase board during the lecture. Students were directed to copy the notes from the board into their science journals.

-Questions revealed student understanding and interest (1)

-Included explicit reference to prior learning experiences and built on existing knowledge (2)

-Responded to students’ questions with knowledgeable feedback (2)

Day 13: Students briefly read over their notes from the previous day. Mary lectured on the process of photosynthesis. During the lecture, students frequently

-Questions revealed student understanding and interest (1)

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asked questions that drew on Mary's expert knowledge. She drew illustrations and wrote down key concepts on the dry-erase board during the lecture. Students were directed to copy the notes from the board into their science journals.

-Responded to students' questions with knowledgeable feedback (2)

Assigned worksheet "Why Do Leaves Change Color in the Fall?" for homework.

Day 14: Mary directed students to read the "Chromatography of Plant Pigments" pre-lab information and instructions. She provided directions for conducting the lab.

Students worked individually to set up the chromatography of plant pigments lab.

Provided answers to their "Why Do Leaves Change Color in the Fall?" homework while students waited on lab results. Those answers provided information that students needed in order to make sense of results of the chromatography lab.

Students returned to the lab to gather data and complete the experiment. They independently answered questions on the lab handout.

Mary spent time helping students learn how to read tables and charts. Referred to textbook sample problem and guided students through answering the questions posed in the book.

Day 15: Mary lectured on cellular energy with a particular focus on cellular respiration. She related the information to what students had previously learned about the structure and function of the mitochondria. During the lecture, students frequently asked questions that drew on Mary's expert knowledge. She drew illustrations and wrote down key concepts on the dry-erase board during the lecture. Students were directed to copy the notes from the board into their science journals.

-Questions revealed student understanding and interest (1)  
-Included explicit reference to prior learning experiences and built on existing knowledge (2)  
-Responded to students' questions with knowledgeable feedback (2)

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Students compared photosynthesis and cellular respiration in a chart provided by Mary, who guided students through answering the questions that identified important places, processes and requirements of each cellular process.

Individual students compared photosynthesis and cellular respiration by creating a table from a list of terms provided by the teacher and categorizing them to distinguish between the processes of photosynthesis and cellular respiration.

Day 16: (substitute teacher) Students completed five worksheets that covered key concepts of cellular energy.

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### Narrative Summary

The narrative that describes Mary's instruction in depth was provided to describe her approach to instruction and the frequency and her use of formative assessment practices. Notice that Mary's primary mode of instruction was lecture, which was sometimes followed by laboratory activities, demonstrations or worksheets. Students usually worked individually, but on a few occasions during laboratory activities worked with a partner. A test review and multiple-choice test followed the lecture/lab/worksheet sequence. She did not implement any form of pre-instruction formative assessment activities to determine what students knew about concepts before beginning.

She lectured in a manner that explained concepts systematically, moving sequentially through background information, explaining what is known and how it became known, introducing key terms, and applying concepts to the personal lives of the students as often as possible. She provided extensive detail and background information in each of her lectures. Students asked questions that allowed Mary to gather evidence about their level of understanding, and she wove their ideas and questions into her lectures as she explained difficult concepts. This practice of using their ideas and



understanding as an integral part of her lecture, demonstrated a level of formative assessment as she responded to students' interest, ideas and knowledge.

On day 12, the narrative describes a test analysis Mary directed students to complete to help them examine their areas of strength and weakness, a move to help students take responsibility for their own learning.

Overall, Mary's use of formative assessment was limited, as illustrated in the narrative. For the most part, her formative assessment practices involved the use of student questions to ascertain their knowledge level and she was responsive by providing lectures that acknowledged and built on their questions, interest and level of understanding.

### Snapshots of Teaching Events

Specific communication events that occurred during the course of the unit warranted further analysis to help reveal the nature of teacher-student and student-student discourse that took place. The following events highlight patterns of communication and the degree of learner- or teacher-centered discourse. A detailed description of each event is given along with an Interaction Analysis coding sequence graph, matrix table and analysis of findings.

#### Event 1 – Day 2

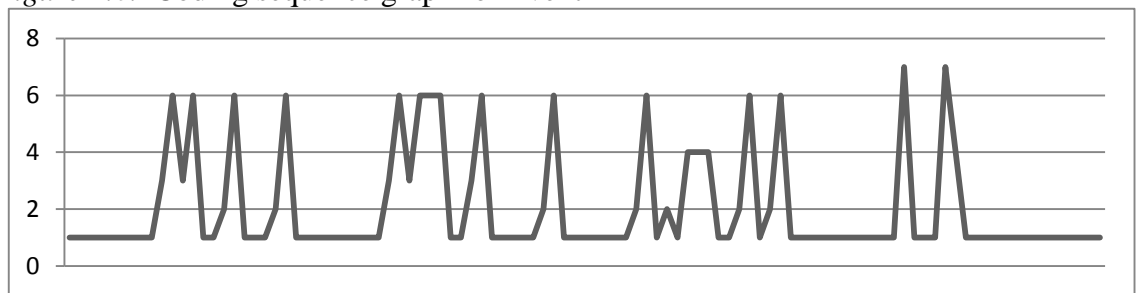
Mary began the class by reviewing content students had learned the day before about the cell, which led into a discussion about the plasma membrane. Mary drew diagrams on the dry-erase board to illustrate key points as she taught about the structure

and function of the plasma membrane. As she lectured, she frequently referred to and built on the lessons from earlier in the year. She frequently asked questions that called for group responses and used examples that were of interest to students' personal lives. For example, when discussing movement of fluid across a membrane, she related the concept to kidney function and homeostasis. During the lecture, she placed a beaker of water at the front of the room and added food coloring to illustrate diffusion. Students asked questions during the lecture and Mary responded knowledgeably and thoroughly.

Figure 4.6 and Tables 4.11 and 4.12 present a coding sequence graph, an LCIA coding sequence matrix and an LCIA analysis table for Event 1. The graph represents 100 tallies (approximately five minutes), and the LCIA matrix and analysis table provide detailed information for the first ten minutes of the 83-minute lecture.

Recall that in the LCIA, 0 = silence, 1 = direct teacher talk, 2 = convergent questions, 3 = divergent questions, 4 = learner-centered talk, 5 = wait time, 6 = student response and 7 = student initiated talk.

*Figure 4.6. Coding sequence graph for Event 1*



This graph illustrates a consistent pattern of movement from teacher direct talk to student response. Notice that there are two instances of student-initiated talk (7s) at the end of the sequence, indicating that students asked questions or shared ideas, followed by direct teacher talk for a sustained period.

Table 4.11. *Interaction Analysis Coding Sequence Matrix for Event 1.* (Shaded areas represent significant steady state cells, and diagonal shaded areas represent significant transitional cells.)

	0	1	2	3	4	5	6	7
1		144	11	3	2			2
2		4	3	1			10	
3							5	
4		3			8		1	
5								
6		12	1	2	1		2	
7		1			1			
Total	0	164	15	6	12	0	18	2
%	0.00%	75.58%	6.91%	2.76%	5.53%	0.00%	8.29%	0.92%
							Total	217

Table 4.12. *Matrix Summary for Event 1*

	Matrix ratios	Cell patterns
%Teacher talk	90.78	<b>Significant Steady state cells</b>
%Student talk	9.22	[1,1] Direct teacher talk to direct teacher talk
TT/ST ratio	9.850 to 1	[4,4] Learner centered to learner centered talk
DTT to LCTT	13.67 to 1	<b>Significant Transitional cells</b>
Convergent to divergent questions ratio	2.5 to 1	[1,2] Direct teacher talk to convergent question
		[2,6] Convergent question to student response
		[6,1] Student response to direct teacher talk

The IA matrix revealed that teacher direct talk occupied nine of the ten minutes that were analyzed during this lecture. Even though there were no significant steady state or transitional cells that involved divergent questioning, the convergent to divergent questions ratio was 2.5 to one, which is less than the ratio of the “typical” classroom (Wilén, 1991). In other words, Mary asked many convergent questions, which is typical, but she also asked questions that were divergent or open-ended that allowed students to

share what they thought or knew with the class. Also notice that [4,4], learner-centered talk was a significant steady state cell, indicating that Mary responded to student comments in a manner that built on or extended their ideas.

## Event 2 – Day 2

During Mary's lecture on diffusion, she often used examples that were of interest to students' personal lives. Students frequently asked questions, which Mary answered knowledgeably. For example, when trying to describe the importance of diffusion in maintaining homeostasis in the human body, she referred to the function of the kidneys in filtering out waste. This prompted questions from the students as demonstrated in the following dialogue:

Student: So, do you know about dialysis?

Mary: Yes, I do know about dialysis. Ok, dialysis is a process or procedure that is done for people when their kidneys quit working. Now, what do your kidneys do for you?

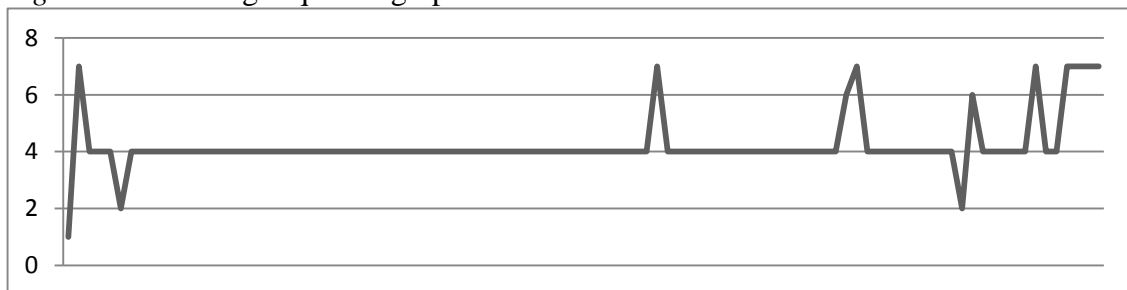
Student: They filter

Mary: Yes, they filter waste products out of the bloodstream. Now let's understand what I mean by waste...

She continued to explain how dialysis works and why filtering by the kidneys is critical to life. She drew diagrams on the board and explained a complicated process in terms students could understand. The original question from the student prompted more questions from other students.

Figure 4.7 and Tables 4.13 and 4.14 present a coding sequence graph, an LCIA coding sequence matrix and an LCIA analysis table for Event 2. The graph represents 100 tallies (approximately five minutes), and the LCIA matrix and analysis table provide detailed information for approximately nine minutes of the 80-minute lecture.

*Figure 4.7. Coding sequence graph for event 2*



This graph illustrates Mary's responsiveness as she answered student questions or comments with learner-centered talk, relating to their interest, needs or knowledge. Notice that the communication begins with student-initiated talk, which may have been a question or comment, followed by learner-centered talk for a sustained period of time, and punctuated with other instances of student-initiated talk.

Table 4.13. *Interaction Analysis Coding Sequence Matrix for Event 2*

	0	1	2	3	4	5	6	7
1		4			1			1
2					1		1	
3								
4		4	2		134		1	11
5								
6					1			1
7					13			
Total	0	8	2	0	150	0	2	13
	0.00%	4.57%	1.14%	0.00%	85.71%	0.00%	1.14%	7.43%
	Total							175

Table 4.14. *Matrix Summary for Event 2*

Matrix ratios		Cell patterns
% Teacher talk	91.43	<i>Significant Steady state cells</i>
% Student talk	8.57	[4,4] Learner centered to learner centered talk
TT/ST ratio	10.667 to 1	
DTT to LCTT	.05 to 1	<i>Significant Transitional cells</i>
Convergent to divergent questions ratio	0	[4,7] Learner centered talk to student initiates talk [7,4] Student initiates talk to learner centered talk

In this lecture, teacher talk occupied approximately eight of the nine minutes that were analyzed, however twice as much teacher talk was learner-centered as opposed to teacher-centered. No divergent questions were asked during this segment of talk, however the students asked questions and shared experiences, which Mary responded to in a way that related to their existing knowledge. She linked the content to their knowledge and incorporated their questions into the learning experience.

### Summary and Significance of Emergent Patterns

The following narrative describes patterns that emerged in Mary's teaching related to formative assessment strategies that revealed what students knew, demonstrated her responsiveness to students' level of understanding, and demonstrated her efforts at activating students as partners in the learning process.

Mary was a very knowledgeable biology teacher who had years of experience teaching regular and advanced placement biology classes. Students took advantage of her knowledge and often asked relevant questions about biology concepts that Mary could answer with a high level of expertise. Over the years, Mary had refined her lectures, and explained concepts in a manner that was logical and easy to understand. Occasional labs confirmed what students had learned during lecture. Her approach to teaching was traditional and instructivist in nature - students worked individually most of the time and were generally passive recipients of Mary's instruction.

### Revealing Strategies

The questions that Mary's lectures inspired revealed the level of student understanding and interest in the topic. Often their questions reflected high-level thinking. For instance, on day 2 when Mary was discussing the plasma membrane and told students that molecules inside the lipid bilayer were hydrophobic, one student wanted to know how water molecules were able to travel through the membrane, given its hydrophobic condition. This type of question revealed that the student had a good understanding of what it meant to be hydrophobic and the apparent problem it would cause the cell, if no provisions were made for certain molecules to pass through.

Her classroom practice was generally consistent with responses she made on her initial Formative Assessment survey. Her mean score on the survey for Category 2: Classroom Dialogue and Questioning Strategies was a 1.75 – a strong use of those strategies. She stated that she often 1) used verbal questioning to determine students' understanding of science concepts, 2) asked open-ended questions including *why* and *how* in whole-class discussions, 3) engaged in extended dialogue with students to learn more about their thinking, and 4) asked students to justify answers in whole-class discussions. The interaction analysis coding system provided evidence that student dialogue was infrequent. In fact, approximately 90% of the talk documented in the LCIAAs was conducted by Mary. However, she was always receptive to student comments and questions. Data show that when there was student talk, it tended to be student-initiated.

#### Responsiveness to Students

Research has shown that teachers with expert content knowledge have the ability to provide feedback to students that is beneficial to their learning (Fox-Turnbull, 2006) and Mary clearly demonstrated the use of expert content knowledge. When student level of understanding was revealed, Mary responded by providing an explanation or elaborating on their existing knowledge. She felt that being able to explain concepts to students in a clear manner was important. In the Formative Assessment survey completed at the beginning of the study, when asked, “What are some factors that may cause you to deviate from your lesson plans?” she wrote, “when students do poorly on something I rethink of a way to explain it again.” She also used the results of her



multiple-choice tests to diagnose common problems that students were having and would re-teach those concepts.

In Mary's lectures, she frequently referred to students' prior learning experiences and related science concepts to their personal lives as illustrated in Event 2. She attempted to present her lectures in a logical sequence that helped students build on what she had presented thus far.

Mary's classroom practices tended to be consistent with her self-reported data on the Formative Assessment survey with regard to instructional response. Her mean score on the survey for Category 1: Instructional Response was 2.5. On the survey, she indicated that she sometimes purposefully collected student data to help her make instructional decisions but she frequently changed her instruction based on student needs and feedback. During the observation period, she did not explicitly prepare and administer planned formative assessment to help her determine the path of her teaching, but she was very responsive to evidence that revealed students' need for re-teaching or clarification.

### Responsibility of Students

At times, Mary promoted self- and peer-reliance by directing students to work with a partner during laboratory investigations. These pairs worked together to answer questions based on their observations and data. During their lab work, Mary would circulate among the students and provide guidance when necessary. She asked them to rely on their data to answer questions and draw conclusions.

She frequently modeled critical thinking skills for students, a practice that helped students develop cognitive and metacognitive abilities. She would “think out loud” as she drew diagrams on the board during her lecture. She also provided opportunities for students to develop their metacognitive skills on day 11 when she had them analyze their test results and document questions that they answered correctly and incorrectly. These practices helped students take ownership of their own learning, an attribute of formative assessment.

On the Formative Assessment survey, Mary reported that she rarely used strategies that fostered student responsibility such as guiding students to generate test questions, write out their learning goals, or involve students in developing rubrics (her mean value was 3.86 in Category 4: Involving Students.) Her classroom practice was consistent with her self-report on the survey.

#### Personal Practice Assessment Theories

Based on the interview with Mary at the end of the observation period, data gathered from observations, field notes, email correspondence, instructional artifacts and analysis of the data, a prevailing personal practice assessment theory (PPAT) that shaped her formal and informal assessment decisions and practices was formulated. The following paragraphs describe her personal theory about assessment, evidence of the theory in practice, and types of knowledge that influenced the development of her theory and in turn, its importance in shaping her instructional decisions and strategies.

Personal practice assessment theory: Students can demonstrate learning by recalling and applying terminology, principles and concepts as explained to them by the teacher.

Data from various sources provided evidence that Mary was committed to the premise that students demonstrate learning by recalling and applying terminology, principles and concepts she had explained to them. Mary spent approximately 60% of her total class time lecturing or leading whole-class discussions such as test reviews, “going-over” the correct answers on their graded homework or quizzes, giving laboratory activity instructions or explaining what results they should have obtained during laboratory activities and what those results meant. Part of her lectures included dissecting vocabulary words into their prefixes, suffixes and root words so that students could use them as needed. Data from the LCIA revealed that the teacher to student talk ratio was typically ten to one. On the survey Mary took at the beginning of the study, she claimed that she would deviate from her lessons plans if students did poorly, by thinking of a new way to explain the concept. In her interview, when asked about a lesson she taught that did not go as planned, she described a lecture where she did not explain probability and chi-square analysis in genetics as well as she should have. A convergence of these data provides evidence that she thought that explaining concepts to students was the most effective way to teach.

To provide evidence of their learning, she sought out their ability to recall or apply terminology, principles and concepts that she had explained to them during her lectures or teacher-led discussions. Students completed a number of worksheets, answered questions on laboratory activity handouts, and took multiple-choice tests that called for factual recall or memorization. In her interview, she claimed that the TAKS

drove her assessment decisions even though she knew there were other ways to assess and would rather assess for understanding than recall. On occasion, some of the questions on the laboratory activity worksheets called for analytical thinking rather than low-level recall. However, the laboratory activities followed Mary's lectures, and were designed to confirm the concepts she had explained, rather than provide opportunities for exploring and discovery.

Mary's propositional knowledge was influenced by folk pedagogy about how students learn, what they needed to learn to pass the end-of-year high stakes test and her role as an educator, which served as the basis for putting this theory into practice. Throughout the years, Mary had accumulated a great deal of content knowledge and appeared to accept the maxim that convinced her that the best way to teach was through explaining, considered an instructionist approach to education. "Instructionists over value content and make the learner the target of instruction" (Cannings & Stager, 2003, p. 2) rather than facilitate the personal construction of knowledge through experiences. Her lectures presented facts, principles and concepts she wanted students to know for the test. Upon reflecting about the effectiveness of her approach, when evidence suggested that student learning was not optimal, Mary tried to think of better ways to explain the concept. Or she reconciled the incongruence by forming generalizations about students that suggested they were not accustomed to critical thinking, therefore it was easier to share her knowledge. Several times during her interview, Mary expressed concern about student apathy, lack of work ethic, inability to solve problems and their desire to be "spoon-fed" rather than their potential to put effort into learning.

## Contextual Elements and PPATs

Several contextual elements had an impact on Mary's PPATs and the implementation of formative assessment in her classroom.

### Facilitating Contextual Elements

Although Mary's use of formative assessment was limited, her exceptional content knowledge and years of experience working with students resulted in her ability to ask insightful questions that revealed student knowledge, and engendered student questions that provided direction for instruction as she responded to students' interests and needs.

### Constraining Contextual Elements

Data gathered in this study suggested that there were several contextual elements that influenced the development and persistence of Mary's PPATs. These elements were her mental model of how students learn, her beliefs about learners, and curriculum requirements such as TAKS.

#### Mental Model of Learning

Mary's beliefs about how students learn constrained her use of learner-centered instruction including the use of formative assessment practices. When asked in her interview "How do students come to an understanding about important biology concepts?" she replied:

I think they've got to feel like it is relevant. I think so much more today than before. I think kids just, in their mind, they've got to think, does this have

anything to do with me? Because I think we are very 'me' oriented, the kids are. Very 'it's all about me'. And I think they have got to feel like it is relevant to them...So I think part of the opening up that little pathway into their brain is, if they're sitting there going 'oh, you know, this is important, this is relevant to me'. I think that is one way that they definitely learn.

From this statement and from observing her practice, there is evidence that she thought relevant issues opened students' minds and then lectures provided what they needed to know about science. Her knowledge was exceptional and she felt an obligation to share what she knew with students, rather than providing experiences to help them construct knowledge on their own or with the help of peers. This mental construct of how students learn guided her decisions about instruction and assessment.

#### Beliefs about Learners

She also believed that students were generally apathetic and not inclined to put forth the effort required to construct knowledge. When asked about inquiry-based learning, she stated:

I would love to be able to start off the school year with just a simple little problem and get the kids in groups and say, I need you to figure out how to solve this. And let the kids start brainstorming. But once again, the kids are like, oh god if it takes much effort, they are like 'I don't want to do this, this is too hard', they'll say.

Therefore, it was simpler for her to adhere to the tenets of instructionism.

On several occasions, Mary mentioned alternative teaching and assessment strategies she used when teaching students in a higher-level advanced placement biology course. When asked to describe an ideal student, she focused on an advanced placement student's work ethic and intrinsic motivation. She mentioned in her interview that

students in her regular classes were different from students in Phoebe's classes. In making this distinction she stated:

Of course, what you have to know is that Phoebe's kids are a very different group. They're pre-ap. They turn in homework and they do some work. I mean, I don't have 50% of my kids turn in homework every time I assign it. I mean, I'm just like – it's a different kind of kid.

It is possible, therefore, that her expectations for "regular" biology students had an impact on decisions she made regarding their instruction as well.

### TAKS and Curriculum Requirements

Mary felt pressured to cover all of the curriculum required by the TEKS in order to help students be successful on the TAKS and claimed in her interview that she had to "teach to the test." Even though she stated in her interview that students could not conduct inquiry experiments because they were "spoon-fed rote memorization and don't know how to think," she perpetuated the very practice she claimed to disavow by teaching through direct instruction, rather than from a learner-centered approach. She stated that students should develop problem-solving skills, but at MISD, that was "just not how science is mainly taught." Therefore, she struggled to cover all of the biology objectives through lecture and comprehensive summative tests at the end of each unit. Again, it is interesting to note that her advanced placement students did not have to pass an exit test to graduate, and statements made in her interview revealed that she taught them through less traditional methods.

## PPATs and the Assessment Development Model

The following narrative describes how the theoretical framework provided by the assessment development model (Figure 1.2) situates Mary's personal practice assessment theory into context. One dominant assessment theory guided Mary's practice: Students can demonstrate learning by recalling and applying terminology, principles and concepts as explained to them by the teacher.

Many internally constructed and externally imposed contextual elements (F) influenced her PPATs (E) and therefore the purpose, planning and implementation of assessment practices. Mary's knowledge helped her know what kinds of questions to ask students, but her mental model of how students learn may have been the reason she lectured most of the time and expected students to listen, take notes during the lecture, and ask questions. She did not provide experiences for students to actively construct knowledge. The laboratory experiments students were confirmatory rather than exploratory. Her contention that students were apathetic and accustomed to being spoon-fed kept her from facilitating a partnership in the learning process, which may have been affected by her expectations from "regular" students as opposed to more advanced students. Finally, she stated that she had to teach to the test – a practice that caused her to feel rushed to cover all of the objectives. Again, she felt that it was more time efficient for her to just explain the concepts, rather than let students construct knowledge.

These contextual elements (F) and her PPATs (E) influenced her decisions about the purpose (A) of the assessment event. Mary's primary purpose for assessment was for accountability, except for the informal observations she made about student knowledge during question and answer sessions as part of her lectures. She planned (B) and



implemented (C) lectures that included questions and infrequent multiple-choice exams that used the same format as the TAKS. When she evaluated homework, labs, or tests, she provided feedback to the students in a whole-class lecture and re-taught concepts that students found difficult. As she reflected on the effectiveness of assessment items, she typically placed the failure on the student's work ethic or attitude, therefore continued to use the same practices each time.

### Formative Assessment Score

Mary's implementation of formative assessment practices during the cell unit was evaluated using the formative assessment performance rubric in Table 3.6. Mary rarely (1) used strategies to probe for useful evidence related to student understandings. Mary's lectures sometimes inspired students to ask questions that revealed what they knew or what interested them, however, the percentage of student talk to teacher talk was negligible, as evidenced by the LCIA. At one time during the unit, she asked students to analyze their test results so that they could know what areas needed more work, but she claimed that it was not a good use of time (students did not care), and did not plan on using it again. However, after summative tests, or after grading labs or homework, she determined what most students missed and would spend time explaining the justification for the correct answer.

Mary occasionally (2) used the evidence she gathered from revealing practices to respond to student needs, build on understanding, and adapt her instruction. In particular, when students asked questions during her lecture, she changed the direction of her instruction to incorporate their comments, ideas or interest. However, since she did not

effectively reveal student understandings, she was limited in her ability to respond to their needs.

Mary rarely (1) used strategies that encouraged students to become active partners with her or with each other in the teaching/learning process. Students usually worked independently at their desks and were passive recipients of information. Mary felt strongly that peer instruction or assessment was detrimental to the learning process. Mary's composite score for items on the formative assessment performance rubric was four of nine, (developing).

### Monica – A Case Study

#### Background Information

Monica, a white female had five years of teaching experience at the time of the study. She received a Bachelor of Science in biology with a minor in chemistry and originally planned to attend medical school, but changed her mind during her undergraduate experience and decided to become a science teacher. Upon graduation, she taught in Texas with an emergency certificate for one year before moving to Florida. She completed a post baccalaureate program to become certified in Florida where she taught middle school science for two years before moving back to Texas where she taught for a year on emergency certification once again. She successfully completed certification requirements for the state of Texas in the summer of 2007. She had been certified to teach in Texas for approximately six months at the time of this study and was in her second year at MISD. She taught biology I, and anatomy and physiology classes.

I chose to study Monica and her students during her fifth period biology class. The class consisted of 19 ninth graders, two tenth graders and one eleventh grader. Two students were classified as special education students, one as gifted and talented and ten as economically disadvantaged. Overall, Monica taught approximately 105 students during the semester observed. See Table 4.15 for demographic information that describes Monica's students involved in this study.

Table 4.15. *Demographic Information for Monica's Students*

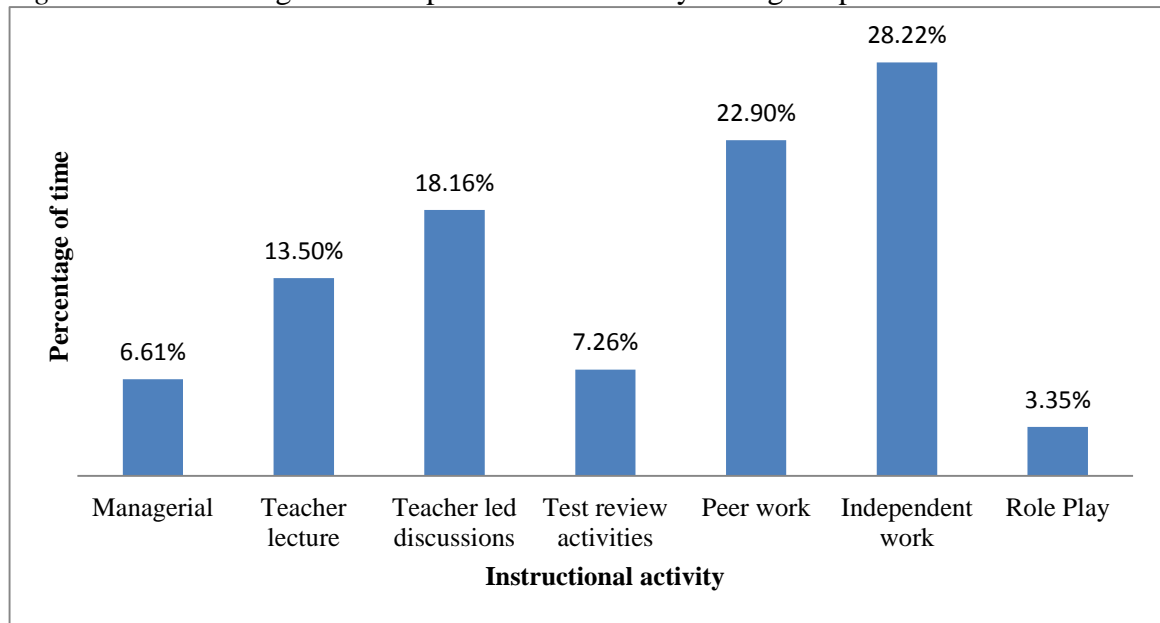
	Female		Male		Both	
	N	Class %	N	Class %	N	Class %
<b>White</b>	6	27.27	6	27.27	12	54.55
<b>Hispanic</b>	1	4.55	7	31.82	8	36.36
<b>African American</b>	1	4.55	0	0	1	4.55
<b>Asian/Pac.Islander</b>	0	0	0	0	0	0
<b>Other</b>	0	0	1	4.55	1	4.55
<b>Total</b>	8	36.36	14	63.64	22	

Monica's science room had individual desks that faced a large chalkboard and a built-in lab demonstration desk with attached teacher desk at the front of the room. Narrow laboratory stations lined the periphery of the room, making lab work difficult at times, due to cramped conditions. A word wall displayed science terms Monica felt were important for students to learn. She posted daily assignments on the chalkboard, wrote lesson standards on a dry erase board near the door, and used the chalkboard and an overhead projector and screen to deliver notes. She also had a TV monitor connected to a computer to show video clips, and so on.

## Classroom Observations

Figure 4.8 shows the percentage of time Monica spent in each type of activity and provides an overall perspective of the instructional practices and patterns that characterized Monica's classroom during her 22.1 hours of instruction.

Figure 4.8. Percentage of time spent on each activity during the period of observation



### Categories

*Managerial* - This category included taking attendance, collecting and returning student papers, and listening to announcements. Approximately 7% of their time was spent on organizational or managerial activities.

*Teacher lecture* – This category included instructional events wherein the teacher presented information to the whole class and students took notes. Monica presented lectures using an overhead projector and prepared transparencies so that she only had to fill in blanks as she taught. Students had a similar handout and they filled in the blanks

or drew illustrations as she lectured. Of the total class time observed during this study, she lectured for approximately 13.5% of the time.

*Teacher led discussions* - These activities, which occupied approximately 19% of the total class time included test reviews, “going over” homework and pre- and post-lab instructions and discussions in a whole-class setting.

*Test review activities* – Approximately 7% of Monica’s class time was spent preparing students for vocabulary quizzes via games or activities in which the students were involved as active participants.

*Peer work* – This category included any activity where students worked with a partner or partners for peer instruction, assessment, review, or to complete laboratory experiments, including the analysis and presentation of data. Much of Monica’s class time (23%) was spent with students working with a peer.

*Independent work* - Independent work included times when students worked individually to complete a learning task, including taking a test or quiz, completing a worksheet, or studying for a test. Most of Monica’s class time (28%) was spent with students working individually.

*Role play* – Approximately 3% of the class time observed included role-plays where students modeled a process as part of the instruction.

### Summary of Time Spent in Activities

Figure 4.8 provided a summary of the percentage of time Monica and her students spent in a variety of instructional activities. Notice that students worked independently almost one-third of the time during this cell unit and teacher-talk including lecture and

teacher-led discussions occupied another one-third of the time. However, students spent approximately 22% of the time working with a peer, either in a structured learning task or in a lab activity. Monica also engaged students by providing vocabulary review games and role-play activities. Her class, although predominantly teacher-centered (as characterized by the amount of teacher talk and independent work) demonstrated a move toward a learning-centered environment as she facilitated opportunities for students to develop self- and peer-reliance during structured peer activities.

Sequence of Lessons and Formative Assessment Use Summary

The narrative in Table 4.16 describes the sequence of instructional lessons and methods Monica employed for two sub-topics within the cell unit.

Table 4.16. *Summary Narrative for Two Subtopics in Monica’s Cell Unit Instruction*

<b>Cellular processes focusing on membrane permeability and molecular transport</b>	
<b>Description of Instructional Activity</b>	<b>Description and Category of Formative Assessment Attribute</b>
<p><u>Day 1:</u> Monica opened the lesson on diffusion with a brief lecture and provided a handout entitled “Diffusion in Cells.” She taught the concept of diffusion in a whole-class discussion as she guided students through answering many of the questions on the handout. Students finished the remainder of the handout for homework. During the discussion, she defined and described terms that students would need to know including diffusion, dynamic equilibrium, surface tension, and osmosis, and elaborated on factors that affect diffusion such as pressure, temperature and concentration. <i>See Snapshots, Event 1.</i></p> <p>Introduced the “Surface Tension” lab to students, which was designed to test the surface tension of water and the effect of additives such as detergent. Monica demonstrated how to carry out procedures and outlined what results students could expect.</p>	

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<p>Students worked in pairs to complete the Surface Tension lab.</p>	<p>Provided students an opportunity for active engagement with a learning partner (3)</p>
<p>Facilitated a brief post-lab discussion and asked students what they learned about the properties of water and surface tension based on evidence gathered in the lab.</p>	<p>Built on student experiences and knowledge (2)</p>
<p><u>Day 2:</u> Monica combined what students had learned about the properties of water during their surface tension lab, with their knowledge of diffusion to introduce a special type of diffusion – osmosis. As she lectured, she filled in the blanks on prepared notes using the overhead projector and students filled in the blanks on a teacher-prepared outline.</p>	<p>Included explicit references to past learning experiences and built on existing knowledge (2)</p>
<p>Introduced the “Plasma Membrane Model” lab, which was designed to demonstrate permeability by using a baggie to model the plasma membrane. She asked students to make predictions about what materials they thought would diffuse through the bag (iodine, cornstarch, water).</p>	
<p>Students worked in pairs to complete the lab. Students drew, labeled, and colored a picture of the plasma membrane in their notes while waiting for substances to diffuse.</p>	<p>Provided students an opportunity for active engagement with a learning partner (3)</p>
<p>Facilitated a brief post-lab discussion and asked students to explain what they learned about diffusion based on evidence gathered in the lab.</p>	<p>Built on student experiences and knowledge (2)</p>
<p><u>Day 3:</u> Monica returned students graded plasma membrane labs and discussed questions that students found difficult as evidenced by their responses on their lab reports.</p>	<p>Assessment-elicited evidence provided direction for instruction (2)</p>
<p>Conducted a vocabulary “Flag” game to help students prepare for a quiz. Students were given pink and yellow “flags.” A definition was given on the TV monitor and two possible answers were given as well, one in pink font and one in yellow font. Students held up the colored flag that they thought corresponded to the correct answer. Monica briefly re-taught concepts as needed based on</p>	<p>-Revealed student knowledge (1) -Assessment-elicited evidence provided direction for instruction (2)</p>

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student responses. *See Snapshots, Event 2.*

Day 4: Monica returned students' Diffusion in Cells worksheet and provided feedback regarding questions that most students found difficult as evidenced by their answers.

Assessment-elicited evidence provided direction for instruction (2)

Conducted a whole-class verbal review of vocabulary terms in preparation for the upcoming vocabulary quiz.

Day 5: Led students in an interactive vocabulary review game. Briefly re-taught concepts as needed based on student responses.

-Revealed student knowledge (1)  
-Assessment-elicited evidence provided direction for instruction (2)

Day 6: Students participated in a competitive game to help them prepare for the upcoming test. In this game, student groups worked together to determine answers to questions posed by the teacher. Monica briefly re-taught concepts as needed based on student responses. The team with the most points at the end of the game received extra credit points on their test.

-Revealed student knowledge (1)  
-Assessment-elicited evidence provided direction for instruction (2)

Day 7: Students studied independently for the upcoming test.

Students took a test over the cell that included nine fill-in-the-blank questions (a word bank was provided), four short answer questions and 23 multiple-choice questions.

Provided learning evidence to teacher and students (1)

At the conclusion of the test, Monica briefly discussed with students the questions they found difficult.

Aided in the development of metacognitive knowledge and strategies (3)

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### **Cellular energy including photosynthesis and cellular respiration**

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#### **Description of Instructional Activity**

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#### **Description and Category of Formative Assessment Attribute**

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Day 8: Monica led the class through a concept attainment activity that focused on the concept of "energy." She asked convergent and divergent questions during the process to

Revealed students' understanding (1)

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teach and to gauge student understanding.

Monica led a whole-class discussion with the students about the novel “Life as We Knew It” by Susan Beth Pfeffer that illustrated in fiction what life would be like on Earth if all photosynthesis ceased. She used this scenario to introduce the importance of photosynthesis to students’ personal lives.

Related concepts to existing knowledge and personal interest of students (2)

Day 9: Monica offered to award students extra credit if they read Pfeffer’s novel. Parents were notified via email of this opportunity for their child.

Provided students the opportunity to take responsibility for their own learning and achievement (3)

Used the jigsaw strategy to help students understand the impact and importance of photosynthesis to their personal lives. Expert groups read segments of “Why Study Photosynthesis” and filled out the corresponding questions on a teacher-prepared handout. They returned to their home group and shared with their peers what they learned. As students shared information, they answered questions on the handout. Monica circulated among the groups asking critical thinking questions and provided feedback to students as needed.

-Related concepts to existing knowledge and personal interest of students (2)

-Built on student experiences and knowledge (2)

-Provided students an opportunity for active engagement with a learning partner (3)

Lectured on cellular energy with a focus on the energy molecule, adenosine tri-phosphate (ATP). As she taught, she filled in the blanks on prepared notes using the overhead projector and students filled in the blanks on a teacher-prepared outline throughout the lecture. During the discussion, she defined and described terms that students would need to know about cellular energy. See Snapshots, Event 3.

At the end of class, Monica used exit cards to reveal what students had learned during class that day. She asked students to answer, “Why is photosynthesis important to you?” Students anonymously recorded their response on an index card and she discussed their responses with the class.

Made student level of understanding and interest visible (1)

Day 10: Monica continued her lecture on cellular energy with a focus on photosynthesis. As she taught, she filled in the blanks on prepared notes using the overhead projector and students filled in the blanks on a teacher-prepared outline.

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Built on student experiences and knowledge (2)

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<p>Monica walked students through a role-play to teach the sequence of steps that occur during photosynthesis. Student volunteers modeled each step of photosynthesis as Monica talked them through the process. After several run-throughs, students were asked to role-play the process without her direction. Student volunteers explained each step as they walked through it. The rest of the class observed and students took turns as participants.</p>	<p>Revealed student knowledge (1)</p>
<p>Students worked independently to complete a worksheet that reinforced the steps of photosynthesis and the molecules involved. Monica circulated among students and provided feedback as necessary.</p>	<p>Built on student experiences and knowledge (2)</p>
<p>Conducted a whole-class vocabulary review for upcoming quiz. Monica provided the definition of the term with multiple-choice answers and called for group responses.</p>	
<p><u>Day 11:</u> Students studied independently for the vocabulary quiz</p>	
<p>Students were administered a 10 question, fill-in-the-blank vocabulary quiz.</p>	
<p>Monica led a whole-class discussion about photosynthesis and guided a group of student volunteers through the photosynthesis role-play.</p>	<p>Revealed student knowledge (1)</p>
<p>Continued the lecture on cellular energy with a focus on photosynthesis. As she taught, she filled in the blanks on prepared notes using the overhead projector and students filled in the blanks on a teacher-prepared outline.</p>	
<p>Introduced the “Plant Pigment Chromatography” lab to students, the purpose of which was to determine what type of plant pigments are found in a leaf. She demonstrated how to conduct experimental procedures and outlined what they could expect as they carried out the investigation.</p>	
<p>Students worked in pairs to complete the investigative portion of the Plant Pigment Chromatography lab.</p>	<p>Provided students an opportunity for active engagement with a learning partner (3)</p>

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Day 12: Monica conducted a brief whole-class discussion regarding the results of their chromatography lab. Explained relationship between pigments discovered in their experiment and photosynthesis

Included explicit references to past learning experiences and built on existing knowledge (2)

Students worked individually or in pairs to complete questions posed on the lab handout. Monica circulated among the students and provided feedback as necessary.

-Built on student experiences and knowledge (2)  
Promoted self and peer-reliance by requiring students to answer questions and draw conclusions based on the evidence provided by their data (3)

Monica lectured on cellular energy with a focus on cellular respiration. As she taught, she filled in the blanks on prepared notes using the overhead projector and students filled in the blanks on a teacher-prepared outline.

Day 13: Monica prepared student for upcoming test through a whole-class discussion that included role-playing, a review of the notes, and the use of manipulatives to model the electron transport chain

In preparation for the upcoming test, individual students compared photosynthesis and cellular respiration by creating a table from a list of terms provided by the teacher and categorizing them to distinguish between the processes of photosynthesis and cellular respiration.

Students participated in a competitive game to help them prepare for the upcoming test. In this game, student groups worked together to determine answers to questions posed by the teacher. Monica briefly re-taught concepts as needed based on student responses. The team with the most points at the end of the game received extra credit points on their test.

-Made knowledge visible (1)  
-Assessment-elicited evidence provided direction for instruction (2)

Day 14: Monica administered a 50 question multiple-choice test covering cellular energy

Provided learning evidence to teacher and students (1)

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## Narrative Summary

This narrative describes Monica's instruction in depth, highlights her approach to instruction, and illustrates the frequency and use of formative assessment practices. To facilitate learning about molecular transport in a cell, Monica's sequence of lessons alternated between lectures that introduced key terms and concepts, and lab activities or worksheets related to the concepts introduced in the lecture. She did not implement any form of pre-instruction formative assessment activity to determine what students knew before beginning instruction. In pre-lab instructions, she tended to tell students what results they could expect to obtain. Students worked with a partner during the hands-on portion of the lab activities, but had the option of working alone or in pairs during data analysis. Following the lab activities, Monica facilitated brief discussions that focused on student results and built on their existing knowledge.

Students frequently worked individually on assignments related to the lesson during class time. Monica consistently graded papers in a timely manner, provided students with feedback and re-taught concepts when necessary. Monica's students also spent time reviewing vocabulary in a whole-class setting or playing a vocabulary review game to help prepare them for a weekly vocabulary quiz or unit test as evidenced on days 3, 4, 5, 6, 10, and 13. The weekly vocabulary terms were not necessarily related to the concepts they had been studying at the time.

During the first part of the unit her approach to instruction and assessment was teacher-centered, although there were occasions that she moved toward a learner-centered classroom as she facilitated peer work and built on their existing knowledge and understandings.

In the second sub-topic, cellular energy, her approach to instruction differed significantly. She began the lesson on day 8 with a concept attainment activity to introduce the concept of energy. This activity allowed her to reveal student knowledge and understanding about energy concepts. She put the concept of photosynthesis into a context that related to student interest by introducing a novel written from a teenager's point of view that made the topic relevant to their personal lives. Students worked in learning groups in a jigsaw activity to learn important concepts before she lectured. Their peer work fostered self- and peer-reliance as they learned from and taught each other. During her lecture, she was able to refer to their learning experience and build on existing knowledge. Students also role-played the steps of photosynthesis as part of the instructional sequence. This activity diverged from traditional lecture, and made their learning visible, however, the role-play generally revealed that students had memorized the steps of photosynthesis, but not necessarily the significance of the steps or of photosynthesis.

Monica implemented effective formative assessment as students completed an exit card about photosynthesis that revealed to her and to the rest of the class what they understood to be important about the process of photosynthesis. This information helped direct future instruction as she referred to their claims during future lectures. The remainder of the lesson on cellular energy was comparable to her approach used during the first sub-topic, molecular transport.

Throughout the unit Monica occasionally used strategies that probed for useful evidence, however most evidence reflected low-level knowledge, rather than understanding. Her most frequent use of formative assessment practices were within

category 2 – she was responsive to students’ level of knowledge and experiences, based on the limited evidence that was available. She also helped students take responsibility for their own learning at times by facilitating learning tasks that involved peer instruction or collaboration on tasks.

### Snapshots of Teaching Events

Specific communication events that occurred during the course of the unit warranted further analysis to help reveal the nature of teacher-student and student-student discourse that took place. The following events highlight patterns of communication and the degree of learner- or teacher-centered discourse. A detailed description of each event is given along with an Interaction Analysis coding sequence graph, matrix table and analysis of findings.

#### Event 1 – Day1

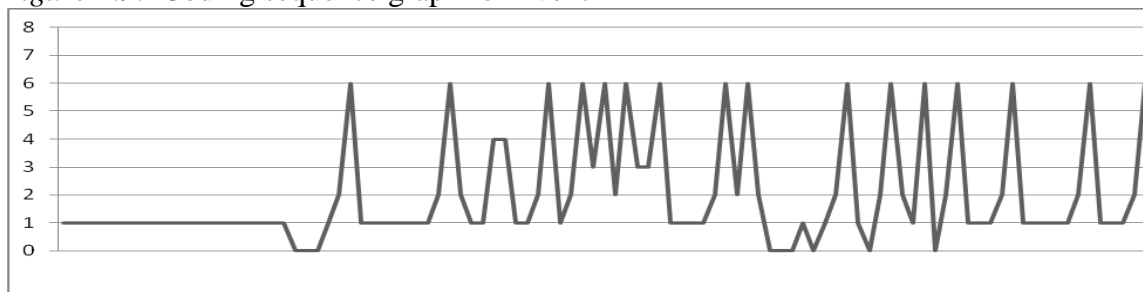
On Monica’s first day of instruction for the cell unit, she began by introducing students to the term “diffusion.” She explained to students that they were going to learn about many cellular processes that help the cell maintain homeostasis. She demonstrated how diffusion worked by spraying perfume at the front of the room and as students gradually began to smell the perfume from their desks, she explained how molecules diffused through the room from an area of high concentration to low concentration until equilibrium was reached. She provided the definition of diffusion for students who completed a worksheet as she proceeded through the rest of the lecture. She asked a series of convergent and divergent questions to help students understand that molecules

move from an area of high concentration to low concentration and that different factors affected the speed of their movement. During the lecture, she provided the definition for other relevant terms such as dynamic equilibrium, surface tension and osmosis.

Figure 4.9 and Tables 4.17 and 4.18 present a coding sequence graph, an LCIA coding sequence matrix and an LCIA analysis table for Event 1. The graph represents 100 tallies (approximately five minutes), and the LCIA matrix and analysis table provide detailed information for the seven-minute “introduction to diffusion” portion of the lecture.

Recall that in the LCIA, 0 = silence, 1 = direct teacher talk, 2 = convergent questions, 3 = divergent questions, 4 = learner-centered talk, 5 = wait time, 6 = student response and 7 = student initiated talk.

*Figure 4.9.* Coding sequence graph for Event 1



Notice in this graph that the lecture begins with direct teacher talk, but proceeds to a series of convergent and divergent questions and student answers throughout. At times, Monica paused to allow students to write notes during the lecture (0s).

Table 4.17. *Interaction Analysis Coding Sequence Matrix for Event 1.* (Shaded areas represent significant steady state cells, and diagonal shaded areas represent significant transitional cells.)

	0	1	2	3	4	5	6	7
0	4	3	2					
1	3	88	11	1	1		3	
2	1	3	1			1	14	
3			1	1			2	
4		1			1			
5							1	
6	1	10	7	2				
7								
Total	9	105	22	4	2	1	20	0
%	5.52%	64.42%	13.50%	2.45%	1.23%	0.61%	12.27%	0.00%
							Total	163

Table 4.18. *Matrix Summary for Event 1*

Matrix ratios		Cell patterns
% Teacher talk	81.60%	<b>Significant Steady State cells</b>
% Student talk	12.27%	[1,1] Direct teacher talk
TT/ST ratio	6.650 to 1	<b>Significant Transitional cells</b>
DTT to LCTT	52.50 to 1	[1,2] Direct teacher talk to convergent question
Convergent to divergent questions ratio	5.50 to 1	[2,6] Convergent question to student response
		[6,1] Student response to direct teacher talk
		[6,2] Student response to convergent question

The IA matrix revealed that most of the communication during this lecture was occupied by teacher talk as illustrated in cell [1,1]. However, during the lecture, Monica asked a series of convergent questions and student responses followed. There were very few instances of learner-centered talk (4s) and no student initiated talk (7s).

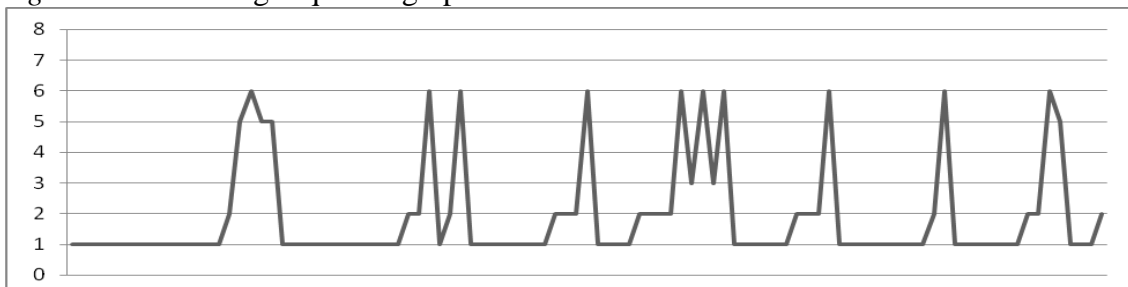


## Event 2 – Day 3

Monica administered weekly vocabulary quizzes to help students prepare for the TAKS. To review and find out how well they knew the definitions, she led students in a vocabulary game. She gave each student two pieces of paper, one pink and one yellow. She provided a definition of the vocabulary word on the TV monitor along with two possible answers, one typed in pink font and one typed in yellow font (one was the correct answer, one was the incorrect answer). Students held up the colored flag that they thought corresponded to the correct answer. If numerous students held up the wrong colored paper, she re-taught the concept and provided ways to help them remember.

Figure 4.10 and Tables 4.19 and 4.20 present a coding sequence graph, an LCIA coding sequence matrix and an LCIA analysis table for Event 2. The graph represents 100 tallies (approximately five minutes), and the LCIA matrix and analysis table provide detailed information for the entire ten minute review.

*Figure 4.10. Coding sequence graph for event 2*



This graph of the communication that took place during the vocabulary review game reveals a consistent pattern of direct teacher talk, followed by convergent or low-level questioning, student responses and a return to direct teacher talk. During sustained

periods of direct teacher talk, Monica was clarifying answers or reinforcing concepts as needed.

Table 4.19: *Interaction Analysis Coding Sequence Matrix for Event 2*

	0	1	2	3	4	5	6	7
0	1	1						
1	1	100	22				2	
2		1	11			1	20	
3							2	
4								
5		2				1	1	
6		21		2		2		
7								
Total	2	125	33	2	0	4	25	0
%	1.05%	65.45%	17.28%	1.05%	0.00%	2.09%	13.09%	0.00%
	Total							191

Table 4.20: *Matrix Summary for Event 2*

Matrix ratios		Cell patterns
%Teacher talk	83.77%	<b>Significant Steady State cells</b>
%Student talk	13.09%	[1,1] Direct teacher talk
TT to ST ratio	6.400 to 1	[2,2] Convergent question to convergent question
DTT to LCTT	0	
Convergent to divergent questions ratio	16.5 to 1	<b>Significant Transitional cells</b>
		[1,2] Direct teacher talk to convergent question
		[2,6] Convergent question to student response
		[6,1] Student response to direct teacher talk

In this event, most of the communication was sustained teacher direct talk, or sustained convergent questions as Monica asked factual recall questions to determine whether or not students knew the vocabulary.

### Event 3 – Day 9

Monica introduced students to the importance of photosynthesis through a jigsaw activity. In the jigsaw activity, expert groups read segments of an article *Why Study Photosynthesis?*, discussed the reading, and worked as a team to answer questions about the reading assignment on a teacher-prepared handout. Afterwards they returned to their ‘home’ groups and shared what they had learned with their peers. Each member of the home group had studied a different segment of the article and the group was able to discuss the entire article and fill in answers to all the questions on the handout. Monica followed the activity with a lecture. She began with a group discussion to bring together what they had learned in the jigsaw.

Monica: Tell me why we should study photosynthesis? Why should we care?

Student 1: Well, because photosynthesis is used to make a lot of our things like clothes, or used to power our cars by like it said, by fossil fuels that are there because plants were, like basically under the ground for millions of years.

Monica: Yes, right. Guys, this group had an interesting reading and it took us back to our earth science days. It talked about coal – fossil fuels are actually made from dead things, plants and animals that have been under the ground for millions of years...without plants, it would be difficult to power so many things that we have because of the electricity, running our cars – we wouldn’t have any fuel for it. What else?

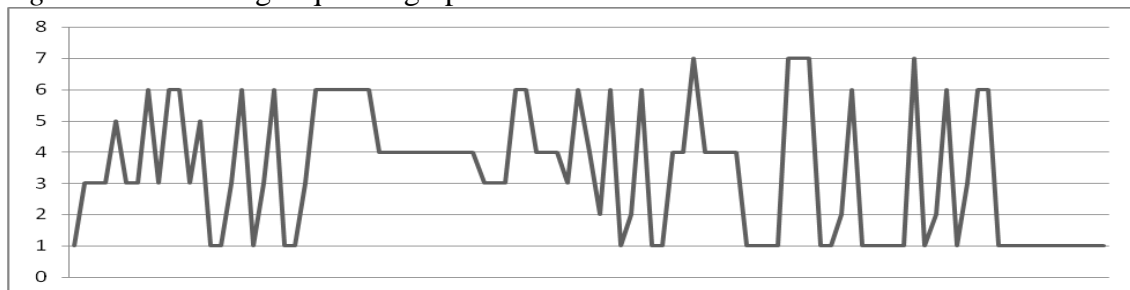
Student 2: They give us oxygen, produce oxygen for us to breathe.

Monica: You're right, without photosynthesis, not only would we die because we didn't have anything to eat, but we would also suffocate with no oxygen.

Notice in the discussion that she used open-ended questions to elicit evidence from students that set the stage for knowledge construction. From there, she explained to students that they needed to study adenosine-tri-phosphate, an important energy molecule.

Figure 4.11 and Tables 4.21 and 4.22 present a coding sequence graph, an LCIA coding sequence matrix and an LCIA analysis table for Event 3. The graph represents 100 tallies (approximately five minutes), and the LCIA matrix and analysis table provide detailed information for the fourteen minute lecture.

*Figure 4.11. Coding sequence graph for event 3*



This graph depicts the patterns found in a lecture following a cooperative learning activity where students worked together to learn and teach each other. Monica asked divergent questions (3s) to determine what students discovered about the importance of photosynthesis. Notice the sustained student response followed by learner-centered talk

(4s) as Monica built on their ideas or comments. Then notice that she moved to direct teacher talk (1s). However, during her direct teacher-talk, there was student initiated talk, that had been noticeably absent in prior lectures.

Table 4.21. *Interaction Analysis Coding Sequence Matrix for Event 3*

	0	1	2	3	4	5	6	7
0	26	11	1					
1	20	121	14	5	2			2
2			1				16	
3				5		2	8	
4		2	1	2	17			2
5		1		1				
6		19		2	3		8	
7		2			2			2
Total	46	156	17	15	24	2	32	6
%	15.44%	52.35%	5.70%	5.03%	8.05%	0.67%	10.74%	2.01%
Total								298

Table 4.22. *Matrix Summary for Event 3*

Matrix ratios		Cell patterns
%Teacher talk	71.14%	<b>Significant Steady State cells</b> [0,0] Silence to silence [1,1] Direct teacher talk [4,4] Learner centered talk to learner centered talk
%Student talk	12.75%	
TT/ST ratio	5.579 to 1	
DTT to LCTT	6.50 to 1	
Convergent to divergent questions ratio	1.13 to 1	<b>Significant Transitional cells</b> [0,1] Silence to direct teacher talk [1,0] Direct teacher talk to silence [1,2] Direct teacher talk to convergent question [2,6] Convergent question to student response [6,1] Student response to direct teacher talk

During this lecture on photosynthesis, the ratio of teacher to student talk is high (5.6 to 1), however of the teacher talk, much of it was learner-centered as Monica built on

student ideas. She also asked approximately the same number of divergent and convergent questions. This is consistent with the event – Monica’s divergent questions required students to explain what they understood and make connections to new concepts. During this sequence, students were taking notes so there were a higher percentage of tallies in the silence categories.

### Summary and Significance of Emergent Patterns

The following narrative describes patterns that emerged in Monica’s teaching related to formative assessment strategies that revealed what students knew, demonstrated her responsiveness to students’ level of understanding, and demonstrated her efforts at activating students as partners in the learning process.

#### Revealing Strategies

Monica dedicated instructional time to a number of different activities including peer work, independent work, and teacher led lectures and discussions. During instruction, she placed a great deal of emphasis on teaching vocabulary terms she thought students should know. To find out if they had mastered the definitions, she frequently used games or activities that revealed their current knowledge. For example, the “Flag” game as illustrated in Event 2, helped her see at a glance what students did or did not know. However, she recognized that this activity was not as effective as she would have liked. In an email that inquired about the purpose and perceived success of activity, she stated:

It was for review, review, review!!! I feel like I have to repeat things 100x in order to get these kids to remember anything! The pink and yellow activity was a

review for their vocabulary quiz. Instead of just going down the list of words, I am constantly in the thinking process of fun ways to review. Since I had seen this at an inclusion workshop once...I thought I would give it a try. I like it, I just don't like that the kids are able to "use" each others' color so it is hard to get a true analysis of who knows and who doesn't. If this was an end of section review, I probably would have used something where I could really tell who knew it and who didn't....So this game was so that I would know that kids were studying the right words and to give them some memorization strategies (you can probably tell that I am ALL about memorization strategies).

Even though the activity was directed toward lower-level thinking rather than understanding, her communication reflected the desire to reveal what students had mastered, an attribute of formative assessment. Monica recognized that this strategy had limitations. When she asked students to hold up a colored flag, some students would wait to see which flags their classmates displayed and would follow suit. She recognized that this limited her ability to obtain valid evidence of student knowledge. In the email, she also conveyed the desire to make changes in her instruction based on evidence gathered from students during the activity, in other words, she planned to respond to assessment-elicited evidence to change her teaching.

During the unit, Monica used other games that were similar to the flag activity to help students learn or reinforce vocabulary terms. She kept all students involved during these activities. For example, the test review activity on days 6 and 13 involved students working together to determine answers to questions posed by the teacher (written on an index card and randomly chosen by the student.) Students conferred with their team members and then offered their answer. If students struggled with an answer, Monica would re-teach the concept or suggest a way to help them remember the definition. At the end of the activity, the team with the most points received extra credit on their test. Although this activity focused on memorization of terms, or knowledge-level content

rather than understanding, Monica used practices to reveal what they knew so that she could adjust her instruction.

Monica used other strategies as well to reveal student knowledge or understanding. For example, at the beginning of the lesson on cellular energy on day 8, she led students through a concept attainment activity. This activity provided examples (in a category titled *yes*) and non-examples (the *no* category) of a concept Monica wanted students to learn. Each *yes* example had common attributes and Monica asked students to look for patterns to determine what all the *yes* examples had in common. As she displayed different examples, students indicated whether they thought the example belonged in the *yes* or a *no* category. After students were able to categorize several examples with accuracy, they determined the common attributes and Monica led them to understand that the *yes* examples all represented the term “energy.”

When asked about the purpose and perceived success of the activity, Monica stated that she wanted to pique students’ interest about energy before she began instruction. She also stated that this activity made her realize that some students did not understand the relationship between energy found in the food they eat, and the function of energy in their cells. She made a point during subsequent lectures to relate food consumption to cellular function. This informal formative assessment strategy provided insight into students’ level of understanding and guided future instructional decisions.

Another strategy employed by Monica to reveal student understanding made use of exit cards at the conclusion of a lesson about photosynthesis. At the end of the class period, Monica asked students to answer the question “Why is photosynthesis important to you?” on an index card. Students anonymously recorded their response and Monica



discussed their ideas with the class. This activity revealed what students had learned in the lesson that day as it related to their personal lives. In an email correspondence, Monica wrote that she used the exit cards “as a quick formative assessment to see if they got it.” She went on to explain that the cards helped her feel confident that she had accomplished her goal during instruction that day.

Monica also used role-playing to help students learn the steps of photosynthesis. She explained that she thought this approach would help visual learners understand the process. Again, this process evaluated low-level knowledge or the ability to memorize steps, however, it also allowed her to see where students were in their knowledge of the process and provided opportunities to clarify or re-teach when necessary.

Monica’s practice was somewhat consistent with her self-reported practices on the Formative Assessment survey she complete before the observation began. In the survey, she reported a very high use of questioning and dialogue strategies that revealed student knowledge and understanding (her mean score on the survey was 1.0 in Category 1: Classroom Dialogue and Questioning Strategies.) Monica did ask divergent questions that were revealing about their level of understanding from time to time, but as evidenced by the LCIA, students rarely talked about their ideas or knowledge for a sustained length of time. Although she may have encouraged or welcomed student ideas, they did not take advantage of the opportunities, which limited Monica’s ability to know where they were in their learning.

## Responsiveness to Students

Monica responded to student understanding as demonstrated during lectures, lab activities and post-lab discussions. She provided learning experiences that built upon each other in a logical sequence and had students draw upon their experiences to make connections about difficult concepts. For instance, she 1) introduced diffusion in a lecture, 2) guided students to understand the nature of a semi-permeable membrane through a lab activity, and 3) highlighted the unique properties of water through a lab activity. Then she tied these three concepts together to introduce a special type of diffusion – osmosis, the diffusion of water through a semi-permeable membrane.

She was responsive to student needs, abilities and knowledge in several ways. For example, during post-lab discussions she asked students to refer to their data to answer questions and used their evidence to teach concepts. She frequently provided verbal feedback to students regarding the accuracy of their work and re-taught concepts as needed. During Monica's lecture about photosynthesis on day 9, she responded to students' ideas and knowledge they had gained through their participation in the jigsaw activity, as demonstrated in the LCIA for Event 3. In an email correspondence, Monica explained how evidence of student learning changed her instruction. She stated that the jigsaw activity provided evidence that students did not understand the role that plants played in the formation of fuels, which prompted a change in her lecture to clarify and reinforce these concepts.

Additionally, she related content to their personal lives by introducing a novel that helped students understand what life would be like without photosynthesis. Although not

many students took advantage of the opportunity to gain extra credit, discussion of the book led students to think about a scientific process from a personal perspective.

In Monica's survey, she reported that she was very responsive to student needs, abilities and level of understanding (her mean value was 1.0 on the survey in Category 1: Instructional Response). She demonstrated this by changing the pace or direction of her instruction when she recognized the need. However, during this study, she did not implement any pre-test or assessment strategies to obtain evidence of student learning to help direct her instruction, which is inconsistent with her self-report.

#### Responsibility of Students

During this observation period, Monica's students spent approximately 23% of their class time in group work. Group work can facilitate peer interaction and learning, and at the same time, result in increased student responsibility for their own learning and that of their peers. Monica frequently assigned students to work together during lab activities, vocabulary or test reviews, or other learning activities. For example, the jigsaw activity on day 9 promoted self- and peer-reliance, as students were responsible for learning information in their expert groups and then returning to their home groups to teach their peers. Monica explained that she decided to use this strategy because the amount of information they needed to learn was extensive and she did not want students to become overwhelmed.

Overall, Monica's classroom practice was somewhat consistent with her self-report on the survey. Her mean value on the survey was 4.86 in Category 4: Involving Students in the Learning and Assessing Process. Although she did not help students take

responsibility for the own learning by allowing them to develop test questions, set learning criteria, reflect on their learning in writing, or ask them to write out learning goals, she did help them take responsibility for their own learning in other ways.

### Personal Practice Assessment Theories

Based on the interview with Monica at the end of the observation period, data gathered from observations, field notes, email correspondence, instructional artifacts and analysis of the data, two prevailing personal practice assessment theories (PPATs) that shaped her formal and informal assessment decisions and practices were formulated. The following paragraphs describe her personal theories about assessment, evidence of theories in practice, and types of knowledge that influenced the development of her theories and in turn, their importance in shaping her instructional decisions and strategies.

Personal practice assessment theory 1: Students can demonstrate learning in a variety of ways.

Data from various sources provided evidence that Monica accepted the premise that students could demonstrate learning through various means. During the cell unit, Monica varied activities frequently, which allowed students to demonstrate their learning in different contexts and through different modes and provided opportunities for informal assessment through methods other than paper and pencil tests. For example, the role-play on day 10 allowed students to physically act out the steps of photosynthesis and demonstrate their knowledge regarding molecules involved in the process and the sequence of the steps. Students demonstrated knowledge through laboratory activities,

quizzes and tests, worksheets, exit cards, vocabulary games, a jigsaw activity and a concept attainment activity. Data from Figure 4.7 illustrated that Monica varied her classroom activities and presented material through several different means. However, the outcomes achieved through these activities tended to be at the factual rather than conceptual level.

Propositional knowledge from a normative perspective appeared to inform and shape Monica's assessment theory and practice. Monica stated in her interview that she thought all students "could prove learning to you in one way or another" so to be fair, she used assessment tools other than paper and pencil tests. She assessed in a way that she thought was equitable to all students and as a result, students had a variety of ways to demonstrate their learning.

Personal practice assessment theory 2: Students' knowledge of scientific facts provides evidence of learning about science and the natural world.

The data collected during the observation period of this study indicated that Monica operated from the premise that students should memorize, define and use scientific terminology, principles and concepts to demonstrate learning about science and the natural world. Each day during instruction, time was set aside to focus on vocabulary words and their definitions during the first few minutes of class. Each week Monica conducted a review game that reinforced student memorization of vocabulary terms, followed by a vocabulary quiz. Vocabulary terms were not related to the content she was teaching at the time. Although Monica spent time each week focusing on vocabulary, in her interview she expressed the concern that she should do more, but was constrained by

time. However, she expected students to learn vocabulary and be able to “speak the language...they have to know the stuff to be able to talk about it.”

As she taught, Monica usually began with a lecture that informed students of the terminology definitions, principles or concepts that were important, rather than allowing them the opportunity to construct the knowledge themselves. Her contention that students should know the terms before exploring or conducting laboratory experiments supported this direct approach to instruction.

Other student activities usually revealed knowledge rather than understanding. For example, the role-play demonstrated students’ knowledge of molecules involved in photosynthesis, and the sequence of the steps, but there was no evidence that students’ possessed a conceptual understanding of the process. A discussion about systems, patterns, form and function, or constancy and change, considered unifying themes in science (NSES, 1996) would have been appropriate at this point to help students develop a deeper understanding of the process of photosynthesis and its place in the natural world.

When preparing students for laboratory activities, Monica typically told students before they began the activity what results to expect, leaving little room for investigation and discovery. Assessment focused on their ability to use terms and concepts she had presented during lecture, rather than on their ability to reason or solve problems. The *National Science Education Standards* (NSES, 1996) contend that students’ “scientific explanations should more frequently include a rich scientific knowledge base, evidence of logic, higher levels of analysis, greater tolerance of criticism and uncertainty, and a clearer demonstration of the relationship between logic, evidence, and current knowledge” (p. 117). However, in this case, laboratory activities tended to be cookbook

type activities that provided limited opportunities for thinking processes as described by the NSES.

For the most part, student tests or quizzes were matching or multiple-choice tests that called for factual recall and memorization, rather than higher-order thinking. However, a few questions on a summative test required an understanding of cellular processes. For example, she asked, “Why is the polar property of water important?” and “Between which cell types is the difference greater – plant and animal cells or prokaryotic and eukaryotic cells? Give a reason for your answer.”

At times during the study, Monica demonstrated a shift towards a learner-centered approach that fostered a deeper understanding of cellular biology. The jigsaw activity and exit cards on day 9 resulted in a modest degree of conceptual understanding and some opportunities for Monica to assess student learning. The jigsaw activity provided students an opportunity to work together to discover the importance of photosynthesis to their personal lives before Monica lectured. The interaction analysis for Event 3 demonstrated that Monica reached a high degree of learner-centered talk as she clarified, refined and built on what they had learned during the jigsaw activity. The exit cards revealed the degree to which students had been able to make sense of the jigsaw and subsequent lectures.

Folk pedagogy, or maxims appeared to guide Monica as she made teaching and assessing decisions about the development of knowledge as a foundational basis for learning and understanding science and the natural world. These claims are shaped by many experiences and are developed through time in the classroom as a professional, and in Monica’s case, as a student. According to her interview, Monica was a “great

memorizer” and was able to made good grades without always developing a deep understanding the content, as is frequently the case in traditional science instruction.

Too often, teachers lack these kinds of experiences (inquiry learning) as learners of science, having been students in science classes that focused heavily on memorizing facts, without also emphasizing deeper conceptual understanding of subject matter and inquiry as a means of learning science. Because teachers’ pedagogical decisions are mediated by their perceptions of themselves as learners and knowers of science, this personal experience is critical to their understanding of and potential commitment to the tenets of reform. (Smith and Southerland, 2007, p 417)

At times, her decisions were informed by and aligned with theoretical knowledge that undergirds formative assessment practices. For example, the jigsaw activity, followed by exit cards allowed her to teach for and formally and informally assess student understanding.

In contrast to the evidence of this PPAT that was revealed in practice, Monica stated in her interview, “assessment is about acknowledging whether or not a student has learned with understanding.” Also, she asserted “I would love to teach *thinking* rather than vocabulary.” She knew *what* was important in regard to assessment and learning outcomes, but was unable to totally free herself from the norms that have heavily influenced how secondary school biology has been taught traditionally.

Overall, Monica did what she thought was expected, and taught based on what she was accustomed to from her high school and college experiences. She felt an obligation to cover the long list of state objectives and that pressure, combined with the lack of theoretical or strategic knowledge required to effectively teach for understanding, heavily influenced her approach to teaching and, specifically, her use of formative assessment. Theoretical and practical knowledge influenced Monica’s decisions



regarding formative assessment. However, the theoretical knowledge clashed with the maxims she held about the importance of memorization, and the need to prepare students for the TAKS. The cognitive dissonance created by the gap between her theory and predominate teaching strategies resulted in practice-centered inquiry, which caused her to attempt different formative assessment practices and to become increasingly interested in learning ways in to narrow this gap.

### Contextual Elements and PPATs

Several contextual elements had a direct impact on Monica's PPATs and therefore the implementation of formative assessment practices.

#### Facilitating Contextual Elements

Factors that positively influenced Monica's PPATs and therefore facilitated her use of formative assessment included practice-centered inquiry and the autonomy that she maintained at MISD.

#### Practice-centered Inquiry

Monica believed that students should learn science at a conceptual level, but knew that she often taught at a knowledge level. This perceived conflict prompted her to reflect on her practice and student learning, which served as a positive impetus for facilitating the implementation of learner-centered and formative assessment practices. Many researchers (Davis, 2002, Feldman, 2000, Loucks-Horsley, 2003, Smith and Southerland, 2007) argued that teachers must be dissatisfied before change can occur.

Monica was not content with her students' level of success or with her own instructional practices. Her reflective nature caused her to attempt new approaches to instruction. For example, many strategies she used in the classroom were learned in recent professional development trainings, indicating that she was willing to change her practice to improve student learning. Monica constantly adjusted her teaching, not only from year to year, but also from class to class. In her interview, she shared a story about a lesson where she had not properly structured the learning activity, and as a result, students struggled. During the class session, she made many changes based on the evidence of student needs and abilities that she had gathered and carried those changes forward for students during the rest of the day. This reflective and adaptive nature indicated that she was not satisfied with the level of student learning so she made instructional adjustments to meet students at their level to build on their knowledge and skills.

### Autonomy

Another contextual element that facilitated Monica's use of formative assessment was the support that she received from the school administration that gave her the freedom to make decisions about how to teach. She stated in her interview that she had a great deal of autonomy and that she could try new strategies as she deemed necessary, based on her experiences and feedback from her students.

### Constraining Contextual Elements

Other contextual elements shaped Monica's PPATs and constrained her use of formative assessment. These elements were her own personal experiences as a student,

the assessment norms of the school where she taught and state and local curriculum requirements.

### Experiences as a Student

Monica's previous experiences as a student seemed to serve as a barrier to transforming her espoused beliefs about teaching for understanding into practice. Her ability to memorize and use that knowledge to demonstrate mastery carried over into her practice as she made instructional decisions that perpetuated learning habits that were familiar and led her to academic success.

### Assessment Practices at MISD

The data suggested that Monica assessed in a manner consistent with the majority of science teachers at MISD and included a mixed use of formative assessment practices. (See Appendix N for MISD survey results.) The assessment culture, habits and norms of the school may have constrained her development of strong formative assessment practices. MISD science teachers reported on the formative assessment survey that they completed at the beginning of the study, that they 1) frequently (but not often) used the evidence from quizzes, verbal questions or tests to guide instruction, 2) frequently elicited feedback from students through higher-level questioning and whole-class discussions, 3) normally used grades as feedback, rather than written suggestions that moved the learner forward, and 4) rarely involved students as partners in the learning/assessing process. These indicators of an infrequent use of formative assessment

situated Monica in a professional context that would require going outside of the professional norms of the school to implement formative assessment strategies.

#### Curriculum Requirement and Need for Coverage

Monica also perceived that she did not have time to cover all of the state-mandated objectives, therefore she gave formative assessment practices low priority, even if she thought they could be effective. Several times during her interview Monica expressed concern that the curriculum was a “mile wide and an inch deep” but she was obligated to cover it, even if only superficially so that she could prepare students for the TAKS. Covering the objectives left her little time to monitor student progress or use data to determine what students’ level or degree of understanding. For example, in her interview, she stated that she thought benchmarks tests could be a useful tool to help guide her teaching, if she had time to analyze the data. The concern over *coverage* also kept her from fully embracing a formative assessment strategy that she learned at a professional development workshop during the semester. The workshop provided teachers a way to help students analyze their own test results so that they could monitor where they were in relation to learning goals, and make adjustments as needed. Monica used the instrument (after the observation period of this study) and reported that although she thought it was a good idea, it did not work in practice because she did not have time to use it effectively. She stated in an email:

I didn't feel it was effective simply because I feel I would need to spend 2 class periods reflecting and discussing for the kids to really understand what they missed...I think it was not as effective as I would have hoped for two main reasons. 1. I always feel pressure to move on. How many kids have to master photosynthesis to say okay...enough.

However, Monica stated that she planned to try using the assessment tool again and hoped to tweak it enough to make it beneficial to her students and an efficient use of her time.

### PPATs and the Assessment Development Model

The following narrative describes how the theoretical framework represented by the assessment development model (Figure 1.2) situates Monica's personal practice assessment theories into context. Two assessment theories (E) guided Monica's practice; 1) Students can demonstrate learning in a variety of ways and 2) Students' knowledge of scientific facts provides evidence of learning about science and the natural world.

Many internally constructed and externally imposed contextual elements (F), both positive and negative influenced her PPATs and therefore the purpose, planning and implementation of assessment practices. Factors that facilitated her use of formative assessment included her belief that she should reflect on student learning and adapt her instruction accordingly and a level of autonomy that enabled her to implement new strategies as she saw fit. However, several contextual elements constrained her use – her experiences as a student herself, the social norms of the school in which she worked and the pressure she felt to “cover” all of the biology objectives to prepare students for the TAKS.

These contextual elements (F) and her PPATs (E) influenced her decisions about the purpose (A) of the assessment event. For the most part, the purposes of Monica's informal assessment activities (review games, question and answer sessions, role-play) were to determine what her students knew so she could provide verbal feedback and help

them prepare for summative tests. Her formal assessments (quizzes and tests) were typically for accountability purposes. Therefore, she planned (B) weekly vocabulary quizzes, review games, and activities that would allow students to demonstrate their learning in different ways, as well as summative TAKS-like tests. When assessments were implemented (C), she primarily assessed through paper and pencil tests, and informal observations from learning activities and games. She evaluated students to see if they knew low-level information, but was responsive to informal assessment events and provided feedback to help the learner or briefly re-teach concepts when necessary. However, her formal assessment events were for accountability or summative purposes and did not alter her instruction. As Monica reflected on the effectiveness of her assessment practices, (D) she stated that she thought the exit cards were effective to reveal knowledge, but the games were not always valid because they assessed group rather than individual knowledge. Generally, she continued to use the same strategy, even if she was unhappy with it until she was exposed to a new approach, which she was willing to try.

#### Formative Assessment Score

Monica's implementation of formative assessment practices during her cell unit was assessed using the formative assessment performance rubric in Table 3.6. Monica occasionally (2) used strategies to probe for useful evidence related to student understandings. Although she frequently used games or activities to reveal knowledge, these activities tended to uncover low-level knowledge, rather than understanding. However, the exit cards that she used after students had studied photosynthesis probed for

understanding rather than memorization. In Monica's interview, she stated that she recognized the value of the exit cards and planned to continue to use them from time to time.

Monica occasionally (2) used assessment-elicited evidence in a manner that demonstrated responsiveness to students' needs, built on current understanding and adapted instruction as needed. Since Monica did not effectively reveal student understanding, she was frequently limited in her ability to respond. When she recognized the need to adapt her instruction based on informal assessment events, she was responsive to their needs and re-taught concepts, changed the direction of her instruction or related what she was teaching to their current interest or knowledge. However, she did not change her instruction based on assessment-elicited evidence provided on quizzes, tests or other formal probes.

She also occasionally (2) used strategies to encourage students to become active partners with each other and with the teacher in the teaching/learning process. Students frequently worked in groups in learning tasks and in particular, they were able to build self- and peer-reliance during the jigsaw activity regarding photosynthesis. Monica's composite score for items on the formative assessment performance rubric was six of nine (developing).

### Student Achievement

A one-way analysis of covariance (ANCOVA) was conducted to determine if there was a significant difference between checkpoint test scores of Monica and Phoebes' students. The independent variable, teachers with different degrees of using formative

assessment in teaching science, included two groups; Monica's students ( $n=18$ ) and Phoebe's students ( $n=17$ ). The dependent variable was the percentage of correct answers on the checkpoint test and the covariate was the percentage of correct answers on the benchmark exam students completed at the beginning of the school year. Factoring out the benchmark scores controlled the effect of prior knowledge that students brought with them to the classroom at the beginning of the year on their performance on the checkpoint test. It should be noted that the sample size in this research study was rather small, which increased the chance for a type II error – the possibility of concluding that there is no significant difference, when in fact, there is.

A preliminary analysis evaluating the homogeneity-of-slopes and homogeneity of variance was conducted for the checkpoint test overall, the seven subtopics and the three levels of difficulty. The homogeneity-of-slopes assumption was met in all cases, but the homogeneity of variance was met in all cases except three, role of the plasma membrane ( $p = .029$ ), cell structure ( $p = .030$ ) and questions of medium difficulty ( $p = .028$ ). However, as Stevens (1990) indicated, “if the group sizes are equal or approximately equal (largest/smallest  $< 1.5$ ), then the F Statistics is robust for unequal variances. That is, the actual alpha stays close to the nominal alpha (level of significance)” (p. 42). Because the sizes of the two groups were almost same, the results of the ANCOVA were valid.

The adjusted means for the checkpoint scores were ordered as expected (based on their formative assessment use) between the two groups. Phoebe's students had the largest adjusted mean ( $M=66.73$ ) and Monica's students had a lower adjusted mean ( $M=61.14$ ). However, the difference was not statistically significant,  $F(1,32) = 2.066, p$



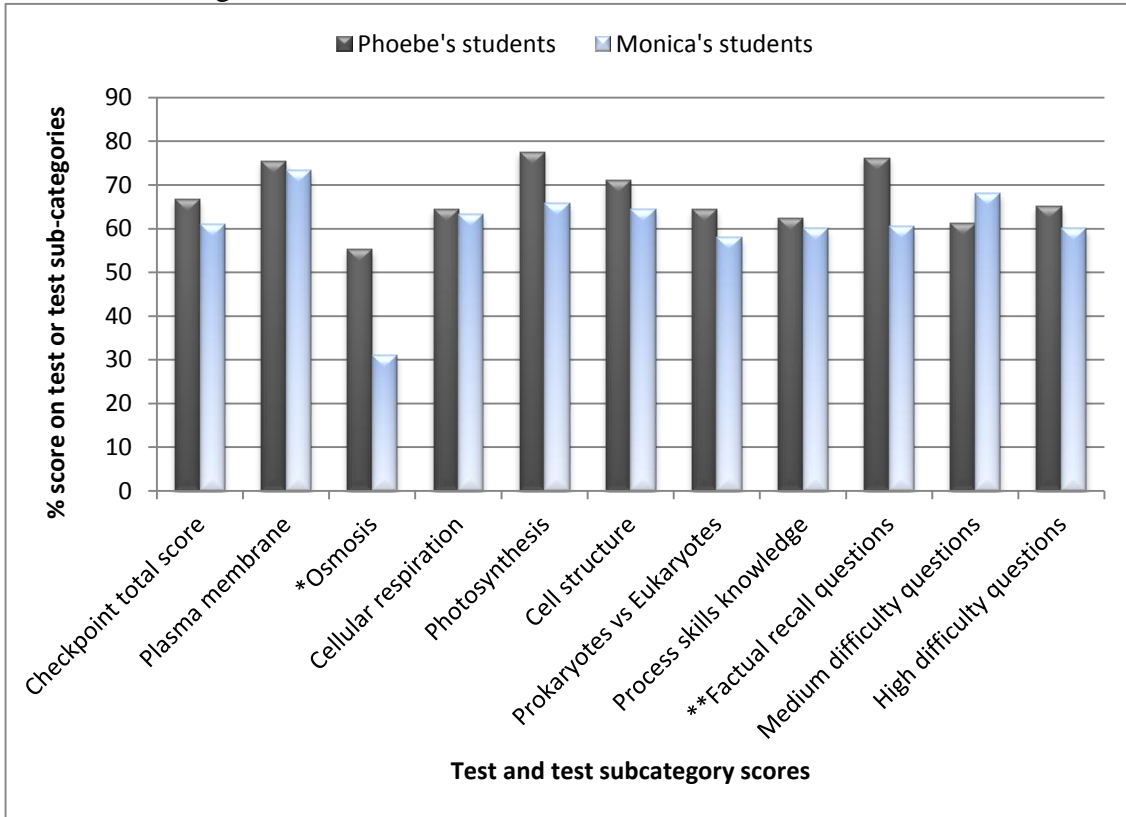
= .16, partial  $\eta^2 = .061$ . Of the ten sub-categories, two were statistically significant: diffusion of water,  $F(1,32) = 5.084$ ,  $p = .031$ , partial  $\eta^2 = .137$  and factual recall questions,  $F(1,32) = 8.019$ ,  $p = .008$ , partial  $\eta^2 = .200$ . In the remaining categories, Phoebe's students scored higher on the adjusted mean in all sub-topics except one. On the questions of medium difficulty, the mean for Monica's students was 68.01 and for Phoebe's students was 61.34. See Table 4.23 and Figure 4.12.

Table 4.23. *Checkpoint Test and Sub-Category Scores and their p Values on ANCOVA*

Checkpoint test and sub-categories	T	Est. Mean score	SD	Adjusted mean score	Std Error	Sig. p value	Partial eta sq.
Checkpoint test score	P	74.539	9.395	66.732	2.524	.160	.061
	M	53.778	16.466	61.142	2.436		
Role of the plasma membrane	P	86.411	16.741	75.432	6.511	.839	.001
	M	63.000	34.169	73.370	6.286		
Diffusion of water (osmosis)	P	52.941	26.69	55.215	6.947	.031*	.137
	M	33.22	22.98	31.074	6.707		
Cellular respiration	P	74.529	32.398	64.376	8.700	.937	.000
	M	53.722	34.666	63.312	8.399		
Photosynthesis	P	82.411	23.932	77.618	5.591	.180	.055
	M	61.278	17.361	65.805	5.398		
Cell structure	P	84.471	16.978	70.986	6.033	.495	.015
	M	51.833	34.826	64.569	5.824		
Comparison of cell types	P	62.882	30.981	64.311	8.160	.618	.008
	M	59.333	27.092	57.984	7.878		
Process skills and cellular energy	P	76.471	25.725	62.243	6.533	.833	.001
	M	46.667	32.899	60.104	6.307		
Factual recall questions	P	79.235	10.912	76.194	3.612	.008**	.200
	M	57.556	15.417	60.428	3.488		
Medium difficulty questions	P	70.588	12.349	61.343	4.600	.354	.027
	M	59.278	25.561	68.009	4.442		
High difficulty questions	P	66.647	17.621	65.129	5.772	.073	.097
	M	46.667	32.899	60.104	5.573		

Significance levels \* $\alpha < .05$  \*\* $\alpha < .01$

Figure 4.12. Adjusted mean scores for students on the cell unit checkpoint test and sub-categories



### Student Motivation

A one-way multivariate analysis of variance (MANOVA) was conducted to determine the effect of the three teachers' classroom practices on two dependent variables, interest and perceived control – subscales of motivation. Significant differences were found among the three teachers on the dependent measures, Wilks's  $\Lambda = .742$ ,  $F(4,100) = 4.023$ ,  $p = .005$ . Table 4.24 contains the means (on a scale of 1-7) and the standard deviations on the dependent variables for the three groups.

Table 4.24. *Means and Standard Deviations on the Interest and Perceived Control for Students in all Three Classes*

Teacher	Interest		Perceived control	
	M	SD	M	SD
Phoebe	5.0781	1.29009	5.5388	.59793
Mary	3.0139	1.42063	4.8800	.96688
Monica	3.9975	1.66462	5.0295	.75422

Analyses of variance (ANOVA) on each dependent variable were conducted as follow-up tests to the MANOVA. The ANOVA on the interest score was significant  $F(2,51) = 8.315, p = .001, \eta^2 = .246$  and the ANOVA on the perceived control was also significant  $F(2,51) = 3.181, p = .050, \eta^2 = .111$ . Post hoc analyses to the univariate ANOVA for the interest scores consisted of conducting pairwise comparisons to determine which teacher's instructional practices affected interest and perceived control most strongly. There was a significant difference between Phoebe and Mary's students in interest and perceived control, but no significant difference between Phoebe and Monica's students, or Mary and Monica's students. See Table 4.25.

Table 4.25. *Means, Standard Error and Significance for Students Motivation*

Dependent variable	Group	Mean diff.	Std. error	Sig.	
Interest	Tukey	Phoebe, Mary	2.0642	.50621	.000**
Interest	HSD	Phoebe, Monica	1.0806	.49416	.083
Interest		Mary, Monica	-.9836	.47867	.110
Control	Tukey	Phoebe, Mary	.6588	.27244	.050*
Control	HSD	Phoebe, Monica	.5093	.26595	.145
Control		Mary, Monica	-.1495	.25761	.831

Significance levels \* $\alpha < .05$  \*\* $\alpha < .01$

Cross-case Analysis

Table 4.26. *A Comparison of Research Results between Teachers in the Study*

	<b>Phoebe</b>	<b>Mary</b>	<b>Monica</b>
<b>Personal practice assessment theories</b>	1) Student understanding is enhanced if students participate as partners with each other and with the teacher in the learning and assessment process 2) Learning is optimized if the teacher assesses for understanding and adjusts instruction accordingly	1) Students demonstrate learning by recalling and applying terminology, principles and concepts as explained to them by the teacher	1) Students can demonstrate learning in a variety of ways 2) Students' knowledge of scientific facts provides evidence of learning about science and the natural world
<b>Dominant forms of knowledge</b>	Theoretical and Strategic	Practical knowledge and maxims	Practical and theoretical
<b>Contextual elements that constrain</b>	1) Cultural norms experienced by students 2) Pace of instruction due to state and local curriculum requirements	1) Mental model of learning 2) Beliefs about student motivation and effort 3) Teaching to the test and need for "coverage"	1) Experiences as a student 2) Assessment norms of the school 3) Teaching to the test and need for "coverage"
<b>Contextual elements that facilitate</b>	1) Mental model of learning 2) Perceived autonomy 3) Support from colleagues 4) Practice-centered inquiry	1) Knowledge of the subject-matter	1) Practice-centered inquiry 2) Perceived autonomy
<b>Implementation of formative assessment</b>	Accomplished	Developing	Developing
<b>Student achievement</b>	High	Unknown	Low
<b>Student motivation</b>	High	Low	Medium

A cross-case analysis was employed to synthesize data and reveal patterns within and across cases. This approach to analysis facilitated examining, identifying, and highlighting similarities and differences across cases with regard to formative assessment use and its impact on student achievement and motivation.

#### Cross-case Analysis of Cumulative Data

Qualitative and quantitative research results were consolidated in order to conduct an inclusive within and across-case analyses of data collected during this research study. Table 4.26 provides a summary of research results for each teacher.

#### Within-case Analysis

##### Phoebe

Notice in Phoebe's case that her PPATs were learner-centered and her instructional decisions reflected a growing body of theoretical and strategic knowledge. The cyclical nature of dissatisfaction, reflection, and adaption, led her to teach and assess for understanding and activate students as agents of their own learning and as instructional resources for each other – an accomplished level of formative assessment use. Even though she struggled with opposing the cultural norms of the students, and experienced pressure to cover all the requirements as dictated by the state, she was able to compensate for them and as a result, student achievement and motivation (interest and perceived control) were high.

## Mary

Mary's PPAT was teacher-centered. It was evident that folk pedagogy influenced the practical knowledge, or maxims, she held that related to how students learn, their lack of motivation and effort, her minimum expectations for "regular" biology students, and the need to teach to the test, which collectively prompted her to teach in a direct manner and assess learning at the factual or knowledge level. Her use of formative assessment was "developing" as she occasionally responded to students' questions in a formative manner. Data from the motivation survey indicated that students lacked motivation (interest and perceived control) as they learned science within this teacher-centered approach.

## Monica

Monica's PPATs represented conflicting approaches to instruction as she moved from a teacher-centered to learner-centered approach. She attempted to allow students to express their learning in a variety of forms, which was consistent with her theoretical knowledge about student learning, but she typically taught at the knowledge level, which reflected her adherence to some premises of folk pedagogy. Her experiences as a student, combined with the perceived pressure to cover a long list of objectives, even if done so superficially, served to constrain the implementation of learner-centered instruction including the use of formative assessment. However, her reflective and adaptive nature compelled her to modify her approach to teaching and assessing if evidence of student learning was marginal. Her use of formative assessment however was still developing.

Student achievement was low, but their motivation (interest and perceived control) was moderate as measured by the motivation survey.

### Across-case Analysis

#### PPATs

Mary and Monica held PPATs that were similar to each other. Their instructional decisions and instruction reflected a PPAT that indicated that students learn science through accumulating facts. However, other PPATs that emerged during this study were distinctly different from one another. Monica held a PPAT that students could demonstrate their knowledge through a variety of ways, and Phoebe's PPATs addressed students' roles in the classroom and the need to assess their understanding and adapt her instruction.

#### Dominant Forms of Knowledge

Although all teachers rely on folk pedagogy at times and hold forms of propositional knowledge, the primary forms of knowledge that guided Phoebe's assessment practices were theoretical and strategic, rather than propositional. Folk pedagogy informed Mary and Monica's practice, although Monica was gaining and applying theoretical knowledge.

### Contextual Elements that Constrained Formative Assessment Use

All three teachers struggled with the pressure they felt to cover all of the state-mandated objectives. However, Mary and Monica felt and responded to the pressure to teach to the test, but Phoebe did not. Phoebe was hindered by student norms and habits, Monica was constrained by her experiences as a student, and Mary was constrained by her beliefs about students' abilities, motivation and effort.

### Contextual Elements that Facilitated Formative Assessment Use

The autonomy teachers experienced gave them freedom to personalize their assessment decisions and strategies. Phoebe and Monica's disposition that caused them to use practice-centered inquiry to improve their instruction facilitated their use of formative assessment. Also, Mary's content knowledge and Phoebe's mental model of how students learn facilitated their use of formative assessment practices.

### Implementation of Formative Assessment

Phoebe's use of formative assessment was "accomplished" while Mary and Monica's were considered "developing."

### Student Achievement

There was no significant difference between student achievement in the two classes on the overall mean, however students in the class with high-frequency use of formative assessment scored higher (but not statistically significant) in all sub-categories



except one on the checkpoint test, and statistically significantly higher in two of the ten sub-categories.

### Student Motivation

Phoebe's students were more interested in learning and felt they had more control over their learning (two sub-scales of motivation) than Monica or Mary's students.

### Across-case Analysis of Sample LCIA Data Results

An in-depth look at teacher/student communication patterns was conducted and documented using the LCIA (Table 3.4) throughout the study. Although the three teachers in this study had distinctly different approaches to teaching, direct instruction was common to all at some point during the unit. In order to compare the nature of their approach to direct teaching, a common topic was chosen. Each teacher's communication interaction patterns were analyzed as they introduced the concept of diffusion.

Representative samples are illustrated in Figures 4.13, 4.14 and 4.15. Each figure represents 100 tallies or five minutes, recorded every three seconds (or less in the case of rapid fire questions and answers) at the beginning of their lecture.



instances of student-initiated talk, indicating that students asked questions or shared ideas, and there were no instances of student-initiated talk in Monica's graph.

These graphs represent typical discourse patterns that were observed and documented throughout the study. They illustrate that all three teachers involved students in their lectures through questioning, but Phoebe's class demonstrated a higher level of involvement as they shared experiences, voiced ideas, made comments or asked questions. Mary and Monica introduced diffusion through lecture before students conducted any laboratory activities. Phoebe, however, lectured after students had conducted a lab that illustrated the properties of diffusion. Conducting the activity before lecturing provided students an opportunity to construct knowledge and the lecture served to clarify and refine ideas.

### Summary

Cross –case analysis results revealed patterns within systems and between cases. There was evidence of a learner-centered approach to assessment as reflected in PPATs, formative assessment use, and classroom strategies that enhanced student achievement and motivation to learn. This learner-centered approach was informed by theoretical and strategic knowledge, which helped mute or lessen constraining contextual elements.

## CHAPTER V

### CONCLUSION

#### Introduction and Background

Formative assessment is a powerful educational tool that has the potential to improve student achievement if used appropriately in the classroom. Its first priority is to promote learning, in other words, it is assessment *for* learning, rather than assessment *of* learning. A formative assessment activity has the potential to promote learning if it provides evidence that is used as feedback by teachers and students in assessing themselves and each other, to modify the teaching or learning activity in which they are engaged. The assessment becomes formative rather than summative when the evidence is used to adapt teaching to meet the learning needs of the student (Black, 2003, p. 2).

The power of formative assessment to improve achievement has been overlooked in the current culture of high stakes summative testing and accountability that emerged after the No Child Left Behind (NCLB) Act was passed in 2001. Although the purpose of NCLB was to improve learning, achievement gains have been marginal (Davis, 2003; Linn, 2000; Nichols & Berliner, 2008). This top-down approach to educational reform neglects one of the most important factors that affects learning, the teacher as facilitator of change. Teachers make instructional and assessment decisions each day based on their own experiences, knowledge, and beliefs, all of which shape their *personal practice assessment theories (PPATs)*. However, those internally constructed elements are not alone in shaping their assessment decisions. Many external contextual elements have a profound effect on their decisions as well. Those internally constructed and externally

imposed contextual elements influence the use of assessment, and subsequently impact student achievement and motivation to learn.

The purpose of this research study was threefold: first, to investigate the purpose, planning and implementation of formative assessment practices of three biology teachers in the context of their personal practice assessment theories. Second, to illuminate contextual elements that constrained or facilitated the use of formative assessment. These goals were accomplished through a collective instrumental case study and cross-case analysis. The third purpose of the research was to determine the effect of formative assessment on student achievement and motivation, which was accomplished through quantitative measures.

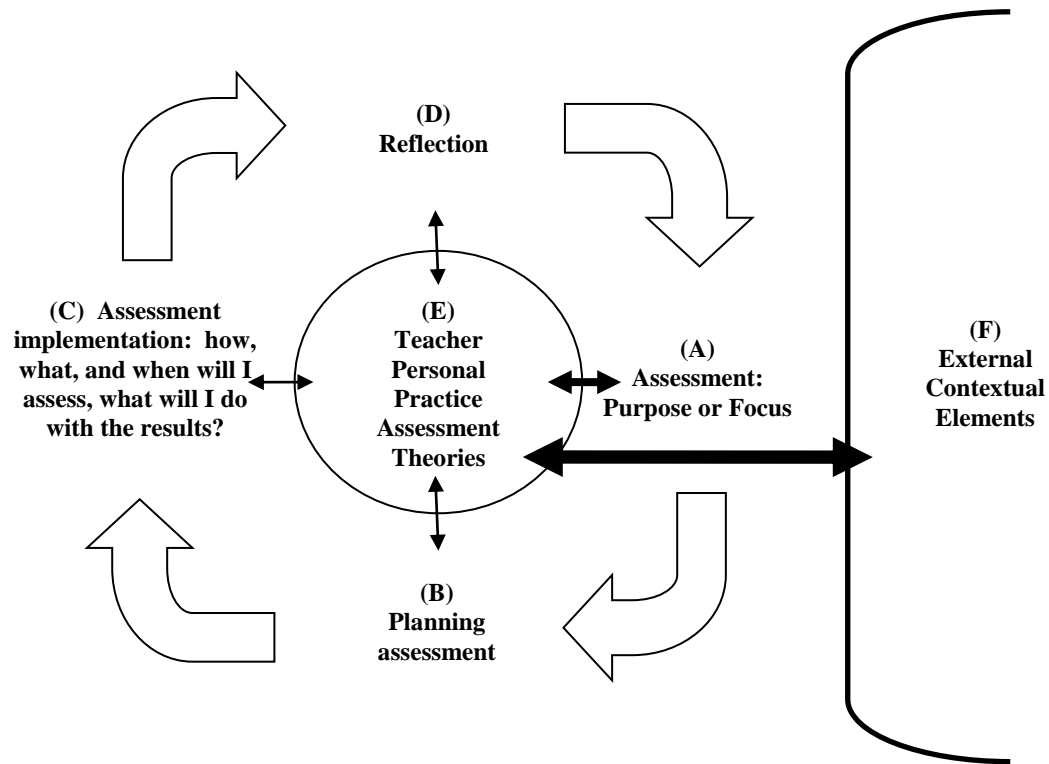
The study showed distinct differences among the three teachers regarding their PPATs and use of formative assessment. Their theories developed through personal and professional experiences, were influenced by their beliefs about learners and learning, and were based on propositional, theoretical or strategic knowledge that played a critical role in converting beliefs or personal theories about assessment into actual classroom practice. Several other factors were identified that facilitated or constrained the use of formative assessment. Their instructional and assessment practices had a direct effect on student achievement and motivation.

### Theoretical Framework

A modified version of Cornett's (1990) curriculum development model based on the impact of personal practice theories served as a framework to investigate the

dynamics between external contextual elements, the teachers' PPATs, and the purpose, planning, implementation and reflection on assessment practices.

*Figure 5.1.* Assessment development model based on the impact of PPATs and external contextual elements



In this model, the teachers' PPATs (E), which are formed through personal and professional experiences, and influenced by beliefs and forms of knowledge, influence their decisions about the purpose or focus (A) of assessment and specific assessment activities. The intent of the activity serves as a basis for planning (B) and implementing (C) assessment. As the teacher reflects (D) upon the success of the activity, they may or may not modify their PPATs and assessment decisions for the future. External contextual

elements (F) positively or negatively influence their PPATs and therefore the entire assessment process.

### Methodology

At the beginning of the research study, a formative assessment survey was administered to 24 sixth through twelfth-grade science teachers at a local school district that had a record of high academic achievement in science education. Three high school biology teachers were chosen for the study based on a review of their formative assessment practices as reported by survey data, informal classroom observations, their assignment to teach biology and their desire and willingness to participate in an extended research project. By confining the cases to teachers within the same discipline, I was able to explore differences in assessment practices during a common unit of study – cellular biology. Additionally, as a former biology teacher, I trusted that my experience and knowledge with respect to biology and biology teaching would provide insight and deeper understanding of classroom dynamics as teachers presented subject matter to their students.

The participating teachers, Phoebe, Mary and Monica, (pseudonyms) had a wide range of classroom experience at the time of the study. Phoebe had been teaching biology for 12 years, Monica for 5 years and Mary for 22 years. Mary was completing her last year of teaching before retirement. Mary and Monica both taught Biology I and Phoebe taught pre-advanced placement Biology, but all were required to teach identical objectives as mandated by the state and their school district, and outlined in locally developed consensus maps. Students were comparable in age and classification.

Quantitative and qualitative data were collected to answer the following questions:

- 1) What formative assessment practices do individual teachers use in the science classroom?
- 2) What personal practice assessment theories influence the implementation of formative assessment by individual science teachers?
  - a. What do individual teachers expect to achieve using specific formative assessment practices?
  - b. What contextual elements constrain or facilitate the use of formative assessment by individual science teachers?
- 3) To what extent does formative assessment affect student achievement and motivation in the typical science classroom?

In this mixed method design, a collective instrumental case study was used to examine in depth the formative assessment practices of Phoebe, Mary and Monica. In each case study, ethnographic field methods were used to examine the teacher and the context in which they taught. Extended classroom observations were conducted to develop profiles of the participating teachers that described in detail the degree, type, and frequency of their formative assessment use. An interaction analysis coding system was developed and used to analyze communication patterns between students and teachers (See Table 3.4). Student achievement and level of motivation were correlated with observation results to provide insight into the meaning, significance and implications of emerging patterns. Teachers' PPATs and forms of knowledge that undergird them were



revealed through semi-structured interviews, and triangulated with observations, field notes, surveys, artifacts and member checking. Semi-structured interviews, brief conversations immediately before or after class, and email communications with the participants disclosed the intent of various assessment practices enacted by the participants, and contextual elements that influenced their PPATs. An administrator interview also provided insight into the purpose and success of programs implemented by the school district in an effort to facilitate formative assessment practices of classroom teachers at their school. A cross case analysis served as a vehicle to compare teaching practices by looking for emerging patterns and themes in the data that were common within and across cases.

### Findings

Data collected during this research study converged to provide convincing evidence that formative assessment use by Phoebe, Mary and Monica varied greatly and that they each held distinctively different personal practice assessment theories as a result of internally constructed factors influenced by externally imposed contextual elements. Of these factors, external contextual elements and forms of teacher knowledge played a critical role in their ability to convert espoused theories about assessment into actual classroom practice. Classroom instructional and assessment practices of each teacher subsequently had a direct effect on student achievement and motivation.

## Formative Assessment Use

A formative assessment performance rubric was designed to evaluate the degree that teachers implemented formative assessment in their instruction. In this research, formative assessment was defined as:

all those activities undertaken by teachers, and by their students in assessing themselves, which provide information to be used as feedback to modify the teaching and learning activities in which they are engaged. Such assessment becomes ‘formative assessment’ when the evidence is actually used to adapt the teaching work to meet the needs. (Black and Wiliam, 1998, p. 2)

During the research study, I focused on three attributes of formative assessment including, 1) revealing strategies teachers used to make learning visible, 2) teacher’s change in behavior in response to assessment-elicited evidence, and 3) the level that teachers helped students take responsibility for their own learning and that of their peers. Analyzing these three attributes provided a balanced view of formative assessment and the interrelatedness of the parts in context of their use. Those attributes are represented in the performance rubric in Table 3.6.

### Phoebe

Phoebe’s use of formative assessment was the most frequent and effective of the teachers in this study. She consistently used a variety of formal and informal strategies to probe for evidence of student understanding (rated a 3 in category one on the performance rubric). She was responsive to assessment-elicited evidence in an ongoing manner (rated a 3 in category two), and shared the responsibility of learning with the students (rated a 2 in category three). The degree of openness, acceptance and trust in Phoebe’s classroom resulted in an emotionally safe environment where formative

assessment thrived. One area that Phoebe could have strengthened during the learning process was the level of student involvement. Although she involved students more than other teachers did in this study, she could have included them to a greater extent in learning and assessment tasks such as setting criteria, setting specific learning goals and formulating a plan to monitor their own progress. Her composite score on the performance rubric was eight of nine (accomplished).

### Mary

Mary's use of formative assessment was limited. She rarely (rated a 1 in category one) used strategies to probe for useful evidence related to student understanding. Direct teacher talk dominated instruction, without explicit attempts to reveal student understanding. Mary relied on her experience from years of instruction and assumed the knowledge level of her students. At times however, she asked questions, or students asked questions during lectures that revealed their knowledge (rated a 2 in category two). These questions provided Mary the opportunity to respond to student needs and build on their understanding, reflecting a modest degree of responsiveness. She rarely facilitated activities that enabled students to take control of their own learning (rated a 1 in category three). Mary felt strongly that peer instruction was detrimental to the learning process. Her composite score on the performance rubric was four of nine (developing).

## Monica

Monica's use of formative assessment fell between Phoebe and Mary's use. She occasionally used strategies that revealed useful evidence related to student learning (rated a 2 in category one). Most of her strategies revealed knowledge, rather than understanding, but still gave her opportunities to respond to student needs, abilities and knowledge to a modest degree (rated a 2 in category two). She also facilitated occasional activities that encouraged students to become active partners with each other and with her (rated a 2 in category three). Monica's composite score for items on the performance rubric was six of nine (developing).

### Personal Practice Assessment Theories and Forms of Knowledge

Too often reform efforts to improve instruction use top-down methods, reflect federal and state policy, and neglect the role of the teacher as a facilitator of change. Yet research is clear that the successes of reform efforts are largely dependent upon the ability or inability of teachers to modify fundamental beliefs about what it means to teach and to learn (Smith and Southerland, 2007). To be more successful, reform efforts in the United States must help teachers' shift from a teacher- to learner-centered classroom that includes the appropriate use of formative assessment. Black and Wiliam (1998a) noted that the implementation of formative assessment calls for deep changes in how teachers view their role as a teacher, in relation to their students and to classroom practice. In other words, they must alter their personal practice theories (PPTs).

PPTs are "the conceptual structures and visions that provide teachers with reasons for acting as they do, and for choosing the teaching activities and curriculum materials

they choose in order to be effective. These are the principles or propositions that undergird and guide teachers' appreciations, decision, and actions" (Sanders & McCutcheon, 1986, p. 55). PPTs have a "powerful and constraining impact on instructional practice" (Gess-Newsome et al., 2003). Those personal practice theories specific to assessment are termed their personal practice assessment theories (PPATs).

PPATs represent teachers' actual assessment theories in *practice* rather than their espoused theories. Often during this study, teachers shared their espoused theories about assessment and learning, yet their practices fell short or were contrary to their espoused theories. Further review of the literature revealed that forms of knowledge possessed by teachers influence which theories are reflected in the teacher's assessment decisions and practices. For example, all three teachers in the study stated that they believed that teachers should "teach for understanding," yet only one of the three teachers was successful in applying this theory to practice.

Shulman (1986) elaborated on forms of knowledge and contended that there are three forms of teacher knowledge: propositional, case or theoretical, and strategic knowledge. Propositional knowledge is based on research, personal experience, or moral reasoning that Shulman referred to as principles, maxims, and norms of teaching. Principles are based on research and can serve as useful guidelines when making educational decisions. Maxims are practical claims that represent the accumulated wisdom of practice or lore of teaching and "in many cases are as important a source of guidance for practice as the theory or empirical principles" (p.11).

Maxims appear to be the result of what Duschl (2007) referred to as "folk pedagogy" or popular belief systems about how students learn, i.e. their mental model of

the learner, and what teachers can do that results in or enhances student learning and understanding. Folk pedagogy represents a teacher's working notion of learning.

The third kind of propositions "reflect the norms, values, ideological or philosophical commitments of justice, fairness, equity, and the like, that we wish teachers and those learning to teach to incorporate and employ" (p.11). Teachers refer to norms of teaching when they make decisions because they are "morally or ethically right" (p.11).

Shulman described case or theoretical knowledge as knowledge, of specific, well documented and richly described events that are developed through a theoretical understanding of teaching and require analogical reasoning and reflection. Both propositional and theoretical knowledge are decontextualized and result in a single rule, which can be problematic when placed in conflict with one another.

Strategic knowledge "comes in to play as the teacher confronts particular situations or problems, whether theoretical, practical or moral where principles collide and no simple solution is possible" (Shulman, 1986, p. 13). Strategic knowledge requires professional judgment - not only of *how*, but of *what* and *why* and goes beyond propositional or theoretical knowledge.

### Phoebe

Phoebe held two dominant PPATs: 1) Student understanding is enhanced if they participate as partners with each other and with the teacher in the learning and assessment process and 2) Learning is optimized if the teacher assesses for understanding and adjusts instruction accordingly. Her PPATs were informed and supported by a combination of theoretical and strategic knowledge.

At almost every opportunity, Phoebe made connections with and among students as she involved them as partners with each other and with her in a wide range of instructional activities. For example, students taught each other, conducted labs together, peer reviewed each other's work, and presented ideas together. Phoebe connected with them as she frequently sought their input about their learning styles, habits, successes and challenges. Overall, she created a classroom culture that was characterized by openness and acceptance that resulted in students working with her and their peers on a daily basis in learning experiences.

Classroom communication patterns, as illustrated in the interaction analyses, consistently showed that the ratio of teacher to student talk was approximately 2:1, much less than the average classroom where teacher to student talk ratio is 4:1 (Newman 2001), indicating that students were active participants in classroom discussions.

Theoretical knowledge served as the foundation for Phoebe's theories and her assessment practices. As a result, she rejected the folk pedagogy or maxims of teaching that; 1) when students work together, they are cheating rather than learning, or 2) students may teach each other incorrectly and cause irreparable harm, or 3) students do not have the knowledge or skills to critique each other, or 4) since teachers are the "expert educators" they should make all instructional decisions rather than seek student input. Phoebe did not accept these propositions. Her instructional decisions were informed and guided by theoretical knowledge that demonstrated the value of a community of learners and the importance of teacher and student partnerships.

Her second PPAT, which stated that learning is optimized if the teacher assesses for understanding and adjusts instruction accordingly, was also demonstrated throughout

the study. Phoebe taught for understanding, assessed accordingly through formal and informal means, and frequently altered her instruction based on assessment-elicited evidence. For example, after participating in several learning activities that focused on the relationship between surface area and rate of diffusion, students were required to transfer their knowledge to a new context outside of the classroom by designing and conducting an experiment at home that demonstrated the principles they had learned in class. Students developed an understanding of the principle as they used their newly gained knowledge in an authentic situation. Students presented their experimental design and results based on the collected data, to their peers and Phoebe during a whole-class discussion. This discussion gave Phoebe an opportunity to informally assess their understanding while clarifying and refining their knowledge. Written reports provided an opportunity for formal assessment with the individual student.

Wiggins and McTighe (2005) argued that, although all teachers claim to teach for understanding, many teachers do not possess a theoretical knowledge of *understanding*, although they hold kinds of propositional knowledge as represented as folk pedagogy. For instance folk pedagogy might propose that 1) hands-on activities effectively develop understanding or 2) students can gain an understanding of a concept through repetitive drill and practice, or 3) if students understand, they can demonstrate their understanding on a paper and pencil test, or 4) knowing is equivalent to understanding. Bransford, et al. (2000) asserted that understanding requires the ability to transfer knowledge and skills to a new context, which Phoebe was adept at doing. Her decisions that created the opportunities for students to make this transfer were congruent with her PPATs and informed by a body of theoretical knowledge related to effective instruction. Her ability



and practice of reflecting on her instructional practice also enhanced her instructional decisions and effectiveness.

There is no distinct boundary between theoretical and strategic knowledge, as there are levels of each, but strategic knowledge ultimately moves beyond theoretical knowledge. Skills and theoretical knowledge are brought together in the development and formation of strategic pedagogical knowledge. Shulman (1986) claimed, “Strategic knowledge must be generated to extend understanding beyond principle to the wisdom of practice” (p.13) and that strategic knowledge or judgment come into play when principles collide and no simple solution is possible. For example, folk pedagogy may contend that “teaching to the test” is unavoidable in the current culture of high stakes testing where students at Phoebe’s school had to pass the state mandated science exit-level test to graduate. However, Phoebe drew upon her theoretical knowledge of how students learn and the importance of teaching and assessing understanding to make instructional decisions. Her wisdom of practice resulted in the merging of seemingly conflicted principles in a manner that was beneficial to students and true to her personal theories of practice.

### Mary

Mary’s assessment decisions were informed and guided by one dominant PPAT, which indicated that students can demonstrate learning by recalling and applying terminology, principles and concepts as explained to them by the teacher. This PPAT was informed by folk pedagogy as reflected in specific maxims.

Mary spent approximately 60% of her total class time lecturing or leading whole-class discussions such as test reviews, “going-over” the correct answers on their graded homework or quizzes, providing laboratory activity instructions or explaining what results they should have obtained during laboratory activities and what those results meant. For example, students completed a laboratory activity using Gummy Bears soaked in water to illustrate diffusion. After students had conducted the lab, she explained to them what should have happened, rather than soliciting input from them regarding their results. Then she provided an explanation of the process of diffusion as related to the gummy bears and then to cells.

Her post-lab discussions, test reviews and lectures were detailed and thorough. Data from the interaction analysis revealed that the teacher to student talk ratio was typically ten to one. Mary thought that explaining concepts to students was the most effective way to teach.

To provide evidence of student learning, she sought out their ability to recall or apply terminology, principles and concepts she had explained to them during her lectures. Students completed a number of worksheets, answered questions on laboratory activity handouts and took multiple-choice tests that mostly required factual recall or memorization. In her interview, she claimed that the end-of-year high stakes test drove her assessment decisions even though she knew there were other ways to assess and would rather teach and assess for understanding than rote-memorization. When asked how her views on how students learn influenced her assessment strategies, she stated:

It probably doesn't influence my assessment strategies that much, because even though there's lots of this stuff that I teach that's relevant, but there's all that other stuff that unfortunately, I'm driven by the TAKS test...going, they (students) may

not think it's relevant, but by god it is for the test so I need to put it on my assessment.

Mary's propositional knowledge about how students learn, what she thought they needed to learn to pass the end-of-year exam, and her role as an educator served as justification for putting this theory into practice. During her career, Mary had accumulated a wealth of content knowledge and her experiences had convinced her, as well as many other teachers, that the best way to share that knowledge was through explaining. Thus, her teaching patterns reflected an instructionist approach to education, which emphasized the value of content and "makes the learner the target of instruction" (Cannings & Stager, 2003, p. 2) rather than facilitating the personal construction of knowledge through experiences. Her lectures presented facts, principles and concepts she wanted students to know for the test. Her propositional knowledge about how students learn appeared to coexist without conflict with what she perceived the goals of education were in light of the high-stakes testing. Her perception that the required tests focused on content and questions that could be answered by knowing definitions or facts, reinforced her teaching and assessment approach.

### Monica

Monica's assessment decisions were informed and guided by two dominant PPATs: 1) Students can demonstrate learning in a variety of ways, and 2) Students' knowledge of scientific facts provides evidence of learning about science and the natural world. Her PPATs were supported by propositional and theoretical knowledge.

During the cell unit, Monica varied her activities frequently, which allowed students to demonstrate their learning in different contexts and through different modes and provided opportunities for informal assessment through methods other than paper and pencil tests. Students demonstrated knowledge through role-plays, laboratory activities, quizzes and tests, worksheets, exit cards, vocabulary games, a jigsaw activity and a concept attainment activity. However, the outcomes achieved through these activities tended to be at the factual rather than conceptual level.

Propositional knowledge from a normative perspective appeared to inform and shape Monica's assessment theory and practice in this context. Monica stated in her interview that she thought all students "could prove learning to you in one way or another" so to be fair, she used assessment tools other than paper and pencil tests. She assessed in a way that she thought was equitable to all students and as a result, students had a variety of ways to demonstrate their learning.

Her second PPAT, the theory that students' knowledge of scientific facts provides evidence of learning about science and the natural world, was also demonstrated throughout the study. Her instruction each day focused on the delivery of facts, principles and concepts about science, followed by ongoing review, and drill and practice that required them to recall low-level facts or cite answers through rote-memorization. Data from the interaction analysis revealed that she typically asked a series of convergent questions that guided students toward the correct answer, rather than asking divergent questions that called for critical thinking. She stated in her interview that she would prefer to teach through inquiry so that students could learn with understanding, but inquiry lessons would put her "five class periods behind...I don't have five class periods,

then I'm three chapters behind...with the amount of content (required to cover as dictated by the consensus map), you can't do that." Therefore, assessment focused on students' ability to use terms and concepts she had presented during lecture, rather than on their ability to reason or solve problems.

At times during the study, Monica demonstrated a shift towards a learner-centered approach that fostered a deeper understanding of cellular biology. A jigsaw activity and exit cards used during her introduction to photosynthesis resulted in a modest degree of conceptual understanding and some opportunities for Monica to assess student learning. Data from the interaction analysis of Event 3 revealed a high degree of learner-centered talk combined with divergent questions embedded with her lecture that followed the jigsaw activity, supporting the assertion that the activity was learner-centered, rather than teacher-centered.

Folk pedagogy appeared to guide Monica's instructional decisions in this regard. These maxims represented the conventional wisdom that she had gained through her experiences as a teacher and as a student. In her interview, Monica stated that she was a "great memorizer" and was able to make good grades without always developing a deep understanding of the content, as is frequently the case in traditional science instruction (Smith and Southerland, 2007).

At times, her decisions were informed by and aligned with theoretical knowledge that undergirds formative assessment practices. Monica stated in her interview, "assessment is about acknowledging whether or not a student has learned with understanding." Also, she asserted "I would love to teach *thinking* rather than vocabulary." She knew *what* was important in regard to assessment and learning

outcomes, but was unable to totally free herself from the norms that have heavily influenced how secondary school biology has been taught traditionally.

Overall, Monica did what she thought was expected, and taught based on what she was accustomed to during her high school and college experiences. Theoretical and practical knowledge influenced Monica's decisions and strategies related to formative assessment during the unit. However, the theoretical and practical knowledge clashed with the maxims she held about the importance of memorization, the need to cover the curriculum, and the responsibility to prepare students for the TAKS. The cognitive dissonance created by the gap between her theory and predominate teaching strategies caused her to attempt different formative assessment practices and to become increasingly interested in learning ways in to narrow this gap.

#### Contextual Elements that Influence Practice

As evidenced throughout this study, assessment decisions made by teachers were complex and influenced by many factors, including internally constructed beliefs or theories based on experience and forms of knowledge. However, those factors were not alone in guiding teachers as they put their assessment theories into practice. There were many externally imposed factors that influenced the teachers' decisions about the use and frequency of assessment, what and how to assess, and what to do with the results. Research studies (Jones, 1997; Lave, 1991, 1993) have identified many external contextual elements including tools of reform such as national or state standards and related high-stakes tests, the physical environment of the classroom and school, the social interaction between teachers, students, administrators and parents and the features that

influence those interactions such as political, social and educational relationships, financial resources, and educational policies.

Internally constructed and externally imposed contextual elements that influenced teachers' practice were determined through interviews, observations, surveys and email correspondence.

### Phoebe

Many contextual elements, both positive and negative influenced Phoebe's PPATs and therefore the purpose, planning and implementation of her assessment practices. Factors that facilitated her use of formative assessment included her beliefs about how students learn through constructing knowledge, the supportive climate in which she worked and her personal nature of discontent with her own teaching or students' current level of learning which led to practice-centered inquiry. Once, during her interview she expressed "I'm never, ever, ever, satisfied...you know, I think that once you get comfortable, that's a dangerous place to be in education."

Contextual elements that hindered Phoebe's practice were the habits, norms and expectations of her students. There is evidence that students do not automatically accept changes in teacher practices or student roles and responsibilities and that change takes time (Hand, Treagust, & Vance, 1997). Students in Phoebe's classes were accustomed to a culture of right and wrong, "making the grade," and competition among students, rather than learning for its intrinsic value. Phoebe continually struggled to help students break free from traditional norms and strive for understanding rather than basing their success on their ability to make a good grade.

Another element that constrained Phoebe's effective use of formative assessment was the pace she felt obligated to keep, in order to teach the required curriculum. This pressure sometimes caused her to be reactive rather than proactive in her planning and implementation of lessons and assessment.

### Mary

Several contextual elements had an impact on Mary's PPATs and the implementation of formative assessment in her classroom. Her knowledge facilitated the use of formative assessment practices in the form of question and answer sessions during lectures that revealed students' level of knowledge. However, her beliefs about how students learn constrained the use of learner-centered instruction including the use of formative assessment practices. Mary thought that relevant issues opened students' minds and then her lectures could provide what they needed to know about science concepts. Her knowledge was exceptional and she felt an obligation to share what she knew with students, rather than providing experiences to help them construct knowledge on their own or with the help of peers. She also stated in her interview that students were apathetic and not inclined to put forth the effort necessary for them to construct knowledge. Therefore, she adhered to the tenets of instructionism.

On several occasions during her interview, Mary indicated that she approached instruction differently for her advanced-placement biology students than with her "regular" students, who she described as unmotivated and not likely to complete assignments. It is possible that her expectations for "regular" biology students had an impact on decisions she made regarding their instruction as well.



She also felt pressure to help students be successful on the end-of-year high stakes exam and claimed in her interview that she had to “teach to the test” even though she thought students would learn best through inquiry. However, she stated that students could not conduct inquiry experiments because they had been “spoon-fed rote memorization and don’t know how to think.” She stated that students should develop problem-solving skills, but at her school, that was “just not how science is mainly taught.” Ultimately, she perpetuated the very practices she claimed to disavow by teaching through direct instruction, rather than from a learner-centered approach.

Mary struggled to cover all of the biology objectives by explaining each one, and subsequently testing students through comprehensive summative tests at the end of each unit. Again, it was interesting to note that her advanced placement students did not have to pass an exit test to graduate, and she taught them through less traditional methods.

### Monica

Several contextual elements had an impact on Monica’s PPATs and therefore the implementation of formative assessment practices. Monica believed that students should learn science at a conceptual level, but knew that she often taught at a knowledge level. This perceived conflict prompted her to reflect on her practice and student learning, which served as a positive impetus for facilitating the implementation of learner-centered and formative assessment practices. This practice-centered inquiry constantly prompted her to adjust her teaching, not only from year to year, but also from class to class. When she was not satisfied with the level of student learning, she made instructional

adjustments to meet students at their cognitive level to build on their knowledge and skills.

Another contextual element that facilitated Monica's use of formative assessment was the support she received from the school administration that gave her the freedom to make decisions about how to teach.

However, several contextual elements constrained Monica's use of formative assessment. Monica's previous experiences as a student seemed to serve as a barrier to transforming her espoused beliefs about teaching for understanding into actual practice. She taught in a manner that was familiar to her, which was teacher-centered rather than learner-centered.

Secondly, the data suggest that Monica assessed in a manner consistent with the majority of science teachers at her school where a mixed use of formative assessment was present. Therefore, the assessment culture, habits and norms of the school may have constrained the development of Monica's formative assessment practices.

Monica also perceived that she did not have time to cover all of the state-mandated objectives and, as a result, gave less time and emphasis to what she thought was valuable, as she prepared students for the end-of-year, high stakes exam.

### Assessment Development Model

The following narrative describes how the theoretical framework provided by the assessment development model situates teachers' PPATs into context. The purpose of the assessment model is to illustrate the interrelatedness of several factors that are involved in making decisions about assessment.

## Phoebe

Figure 5.2 illustrates how Phoebe's two PPATs - students as partners, and assessing for understanding then adjusting instruction (E), were influenced by both positive and negative contextual elements (F). On the positive side, her beliefs about how students learn facilitated her practice of activating students as the owners of their own learning and as instructional resources for one another. She knew that students had the potential to learn from each other as they constructed knowledge, and that both students and teachers could benefit when there was an open exchange of feedback used to move learning forward. Her administration supported her approach to instruction and practice-centered inquiry resulted in her attempts to try new methods of improving instruction and assessment in an ongoing manner.

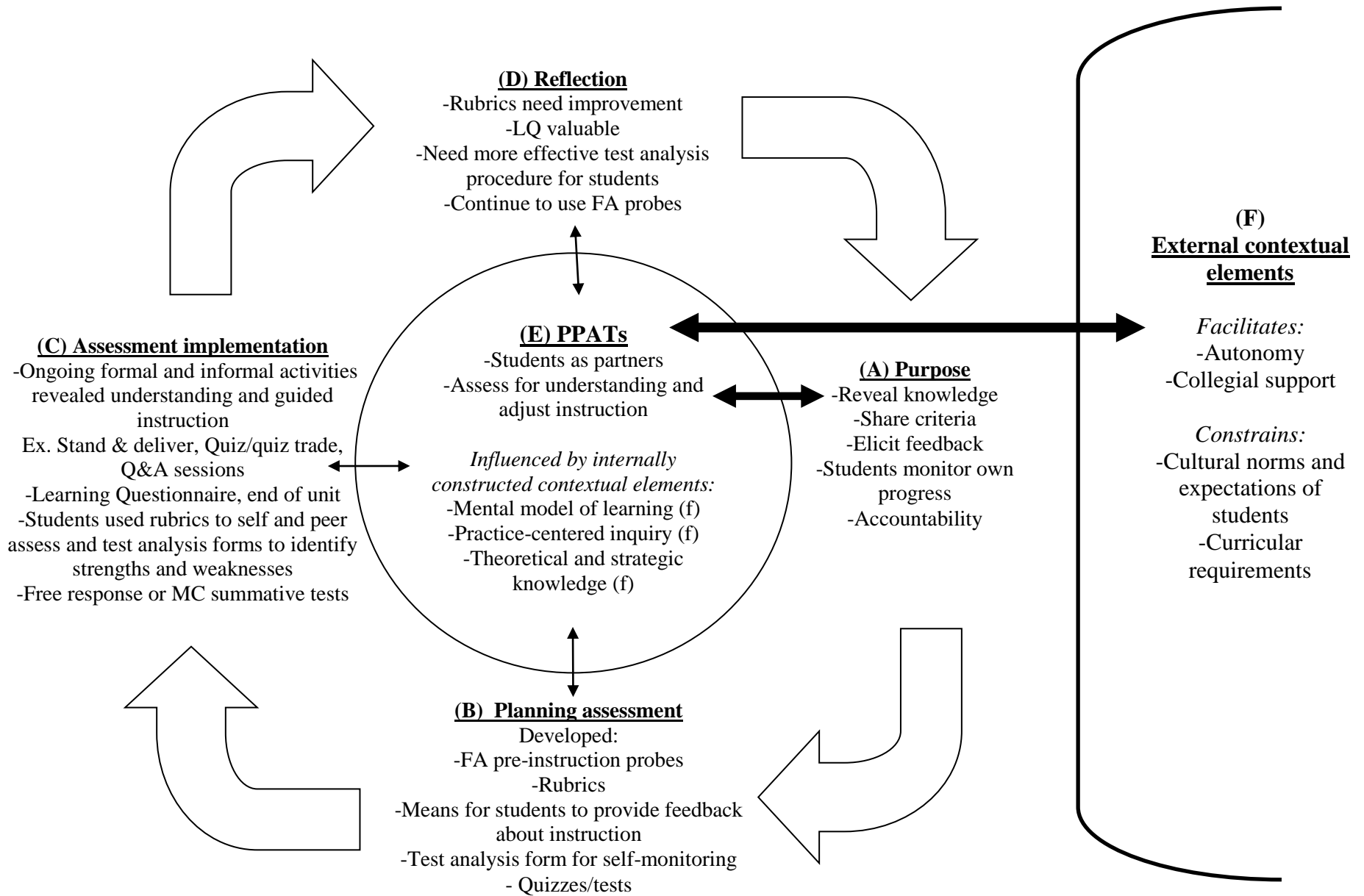
However, the cultural norms and expectations of her students and the demanding pace she felt compelled to keep, kept her from realizing the full potential of formative assessment practices. Students often focused more on grades than on learning, and Phoebe found this frustrating at times as she thought the students' focus created a barrier that hindered her ability to uncover their true level of understanding, which she thought was important as expressed in her second PPAT.

As she dealt with the daily pressures to meet all the requirements of teaching high school biology, at times she reverted to methods that did not reflect her PPATs. For example, she stated in her interview that effective rubrics took time to develop and due to time restraints, she sometimes reverted to using assessment methods that she thought did not check for understanding, but were convenient to use.

These contextual elements (F) and her PPATs (E) influenced her decisions about the purpose (A) of the assessment events, which were varied and included the intent to 1) reveal what students knew so that she could make instructional decisions, 2) share learning criteria with students before starting projects so that they could self and peer-assess 3) elicit feedback from students about the effectiveness of lessons, and 4) provide opportunities for students to monitor their own progress. Therefore, as she planned (B) assessment events, she developed pre-instruction activities that probed for prior knowledge, rubrics that outlined grading criteria, a learning questionnaire for students to assess her effectiveness, quizzes and tests for formative as well as summative purposes and a test analysis forms for students to monitor their progress.

Assessment implementation (C) varied depending on the purpose of the assessment. She used strategies to access student knowledge and used the information to guide future instruction. Students used rubrics to self and peer assess. She frequently administered short answer quizzes to monitor their progress, allowed students to evaluate her teaching, facilitated opportunities for students to analyze their own progress, and used summative assessments for accountability purposes. As Phoebe reflected on her assessment activities (D) she shared that, 1) she needed to improve her rubrics so that they were more than a checklist, 2) she would continue to administer the learning questionnaire because it provided valuable information each year about her students, 3) the test analysis procedure needed work, because she was not sure how to help students master content from previous lessons once the group had moved on to new topics, and 4) she found particular revealing activities very effective.

Figure 5.2. Assessment development model - Phoebe



## Mary

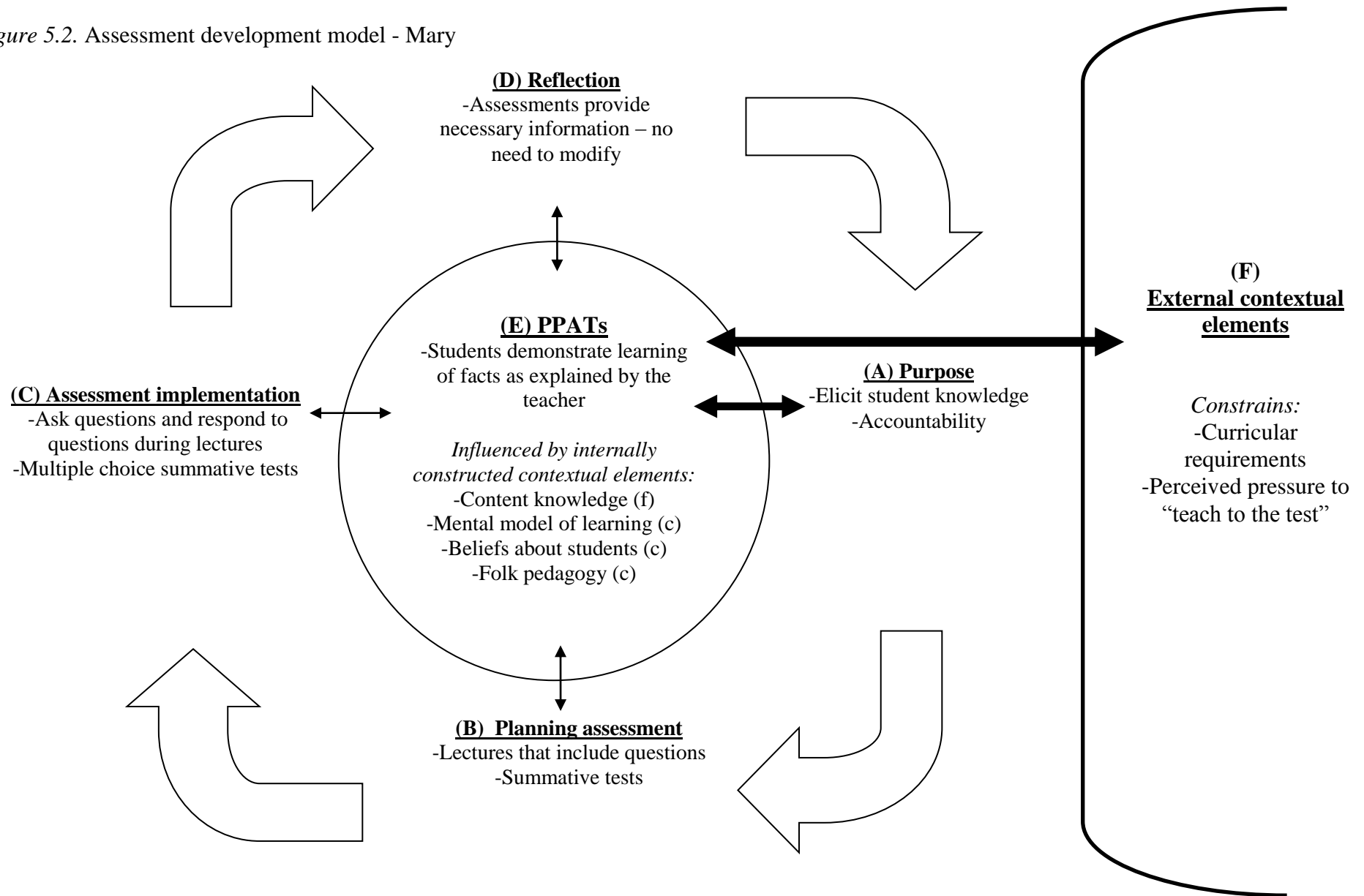
Figure 5.3 illustrates how Mary's PPAT that students can demonstrate learning by recalling and applying terminology, principles and concepts as explained to them by the teacher (E) was influenced predominantly by constraining contextual elements (F). Mary's mental model of how students learn may have served to justify the rationale that revealing students' current level of understanding was unnecessary because her ability to explain would compensate for any misunderstandings held by students.

Secondly, her contention that students were apathetic and accustomed to being "spoon-fed" kept her from facilitating a partnership in the learning process which may have been affected by her expectations from "average" students as opposed to more advanced students.

Finally, she stated that she had to teach to the test – a practice that caused her to feel rushed to cover all of the test objectives. Again, she felt that it was more time efficient for her to explain concepts, rather than let students construct knowledge.

These contextual elements (F) and her PPATs (E) influenced her decisions about the purpose (A) of the assessment event. Mary's primary purpose for assessment was summative rather than formative, except for the informal assessments that she made of student knowledge during question and answer sessions as part of the lectures. She planned (B) and implemented (C) infrequent multiple-choice exams that used the same format as the end-of-year high stakes exam. When she evaluated homework, labs or tests, she provided feedback to students in a whole-class setting and re-taught concepts that students found difficult. As she reflected (D) on the effectiveness of assessment items, she stated that her assessments provided the information that she needed.

Figure 5.2. Assessment development model - Mary



## Monica

Figure 5.4 illustrates how Monica's two PPATs - students can demonstrate learning in numerous ways, and students' knowledge of scientific facts provides evidence of learning (E), were influenced by both positive and negative contextual elements (F). One of the most influential factors that positively affected Monica's practice was her tendency to reflect on student learning and adapt her instruction through practice-centered inquiry. Monica was a relatively new teacher with a developing repertoire of practices. When assessment-elicited evidence indicated student learning was not at a desired level, she made changes based on recently attained instructional practices she had learned at workshops or from peers.

Although she still taught and assessed at a knowledge level most of the time, there were times when she used strategies that moved students toward understanding and was reflected in her PPAT that stated students could demonstrate learning in a variety of ways. Additionally she felt that she maintained a desirable level of autonomy that enabled her to implement new strategies as she saw fit.

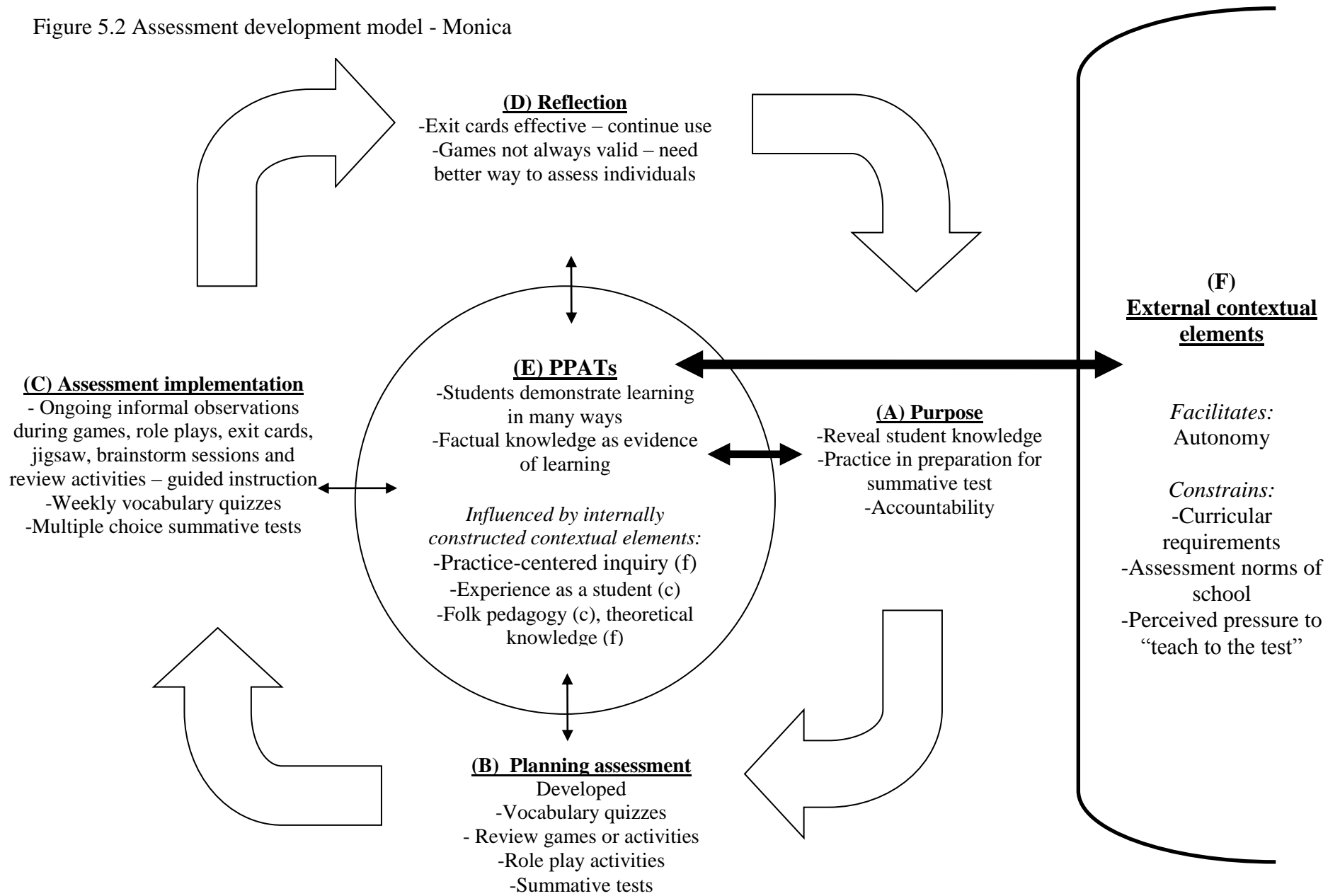
However, several contextual elements constrained her use – her experiences as a student, the cultural norms of the school where she worked and the pressure she felt to cover all of the biology objectives to help students be successful on the end-of-year exam. These constraining factors kept her from translating her espoused theories to theories in practice.

These contextual elements (F) and her PPATs (E) influenced her decisions about the purpose (A) of the assessment event. For the most part, the purposes of Monica's informal assessment activities were to reveal what students knew so she could provide



verbal feedback and help them prepare for summative tests. Her formal assessments were typically for accountability purposes. Therefore, she planned (B) multiple-choice summative tests and weekly vocabulary quizzes, review games, activities that would allow students to demonstrate their learning in different ways. When assessments were implemented (C), she primarily assessed through paper and pencil tests, and informal observations. She evaluated students to see if they knew low-level information, but was responsive to informal assessment events and would provide feedback to help the learner as an individual or briefly re-teach concepts in a whole-class setting when necessary. However, her formal assessment practices for accountability or summative purposes did not alter her instruction. As Monica reflected on the effectiveness of her assessment practices, (D) she felt that the exit cards were an effective means to reveal understanding and that some games and activities were not effective in revealing individual knowledge. She was often dissatisfied with her continued use of the same strategies and their mismatch with her PPATs and was committed to learn new approaches to alleviate or eliminate this mismatch.

Figure 5.2 Assessment development model - Monica



## Student Achievement

A checkpoint test that addressed major cell concepts measured student achievement in Monica and Phoebe's classes. Recall that Mary's students were not included in this analysis because she administered her test immediately after finishing her instruction, due to time restraints and Monica and Phoebe waited six weeks after completing instruction to administer theirs. The test was divided into seven sub-topics. For each sub-topic, three levels (low, medium and high) of questions were developed. Low-level questions required memorization of facts or definitions of terms. Medium-level question typically required students to apply their knowledge whereas high-level questions called for the synthesis of data to make predictions, draw conclusions and so on. Six questions required critical thinking and the analysis of a hypothetical experimental design involving cellular energy and plants.

In the statistical analysis, student's prior knowledge was accounted for, and adjusted out of the means through a statistical maneuver within the analysis of covariance (ANCOVA). Therefore, test results reflected the effect of classroom instruction that took place, rather than students' prior knowledge. Students in Phoebe's classes scored higher on the adjusted means in all categories (sub-topic and level of difficulty) except one, and results were significantly higher on two sub-scales, which had questions that focused on osmosis and a sub-set of low-level, factual recall questions.

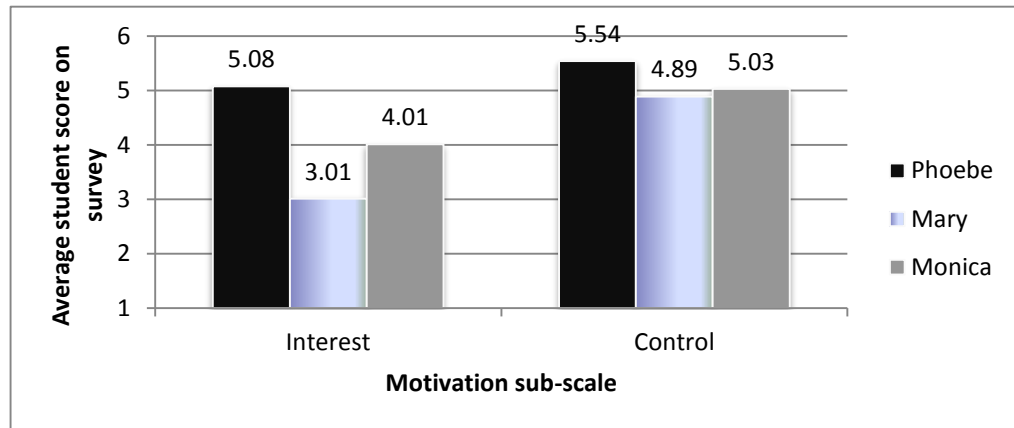
These results provided evidence that Phoebe's instructional practice enhanced student achievement, more so than Monica's practice. Phoebe implemented strategies that revealed students' current level of understanding, she responded to assessment-elicited evidence and facilitated a partnership with students in the learning process.

Although many factors affect student achievement, the evidence gathered in this research study supported the assertion that formative assessment practices enhanced student learning and therefore achievement. It is interesting to note that Monica's students scored significantly lower than Phoebe's on low-level factual recall questions despite her primary focus throughout the unit on helping students memorize vocabulary words. She conducted a bell ringer every day that introduced new terms, administered a weekly vocabulary quiz, and played frequent vocabulary review games. Yet her students' scores were low in this regard. Rather than teaching the words in context of the learning that was occurring at the time, Monica taught the words in isolation and wanted students to memorize them, a practice that evidently did not result in the desired outcome.

### Student Motivation

Formative assessment practices that promote self- and peer-reliance are expected to improve student motivation. Intrinsic motivation of students in all three biology classes was assessed by administering a survey at the end of the unit that was designed to assess their interest in the class and perceived control of their learning – two subscales of intrinsic motivation. There was a significant difference between the data from Phoebe and Mary's classes on both sub-scales, but not between Phoebe and Monica's or Mary and Monica's. However, Phoebe's results were higher than Monica on both sub-scales and Monica's scores were higher than Mary's on both sub-scales. These data indicate that students were more interested in Phoebe's class and felt they had some control over their own learning. See Figure 5.2.

Figure 5.2. Student survey means (range 1 – 7) for motivation sub-scales, interest and perceived control



These results provided evidence of the positive impact of Phoebe’s approach to instruction and assessment on student motivation. Students in her class were immersed in a learning environment that fostered connections and partnerships, which enhanced the positive perceptions of the class and their sense of ownership and control. The data indicated that students who were passive recipients of knowledge, as in Mary’s class, enjoyed learning less and perceived that they had less control over their learning or success in the class. Monica’s students fell in-between the two, which supported the assertion that her use of formative assessment was “developing.”

### Research Questions and Answers

Questions addressed were as follows:

- 1) What formative assessment practices do individual teachers use in the science classroom?

Teachers in this study used a variety of formal and informal formative assessment practices and their individual use of formative assessment ranged from limited, to healthy

and robust. Robust use included strategies that made learning visible through formative assessment probes, student presentations, board work, highly interactive whole-class discussions, and convergent and divergent questions posed by the teacher. The most common mode used by all three teachers to elicit evidence of learning was through question and answer sessions that allowed teachers to respond by clarifying and building on student knowledge during whole-class discussions. There was also evidence that teachers changed their instruction based on feedback from students. Students were involved as partners in the process by working with peers in learning and assessment tasks including peer review, conducting labs together, critiquing each other's work, and developing and sharing ideas with the class.

Benchmark data did not appear to be used (as planned by the administration) to make instructional decisions. Also, notably absent from the process were planned formative assessment strategies that provided students the opportunity to set learning goals and monitor their own progress during the year, informative feedback provided by teachers, or strategies to monitor student progress on individual objectives.

2) What personal practice assessment theories influence the implementation of formative assessment by individual science teachers?

The following list outlines the PPATs revealed during this research study that influenced the implementation of formative assessment practices.

- a. Student understanding is enhanced if students participate as partners with each other and with the teacher in the learning and assessment process
- b. Learning is optimized if the teacher assesses for understanding and adjusts instruction accordingly
- c. Students demonstrate learning by recalling and applying terminology, principles and concepts as explained to them by the teacher
- d. Students can demonstrate learning in a variety of ways
- e. Students' knowledge of scientific facts provides evidence of learning about science and the natural world

It is important to note that two of the five PPATs hindered the use of formative assessment.

3) What do individual teachers expect to achieve using specific formative assessment practices?

For the most part, teachers used formative assessment strategies during the cell unit to reveal what students knew about the content so that they could address deficiencies as needed. However, at times teachers hoped to activate students as owners of their own learning or expected to gain useful feedback from students so that they could make informed and appropriate instructional decisions.

4) What contextual elements constrain or facilitate the use of formative assessment by individual science teachers?

Forms of teacher knowledge were identified as internally constructed contextual elements that influenced the ability for teachers to put espoused theories into practice, which in turn affected their use of formative assessment. Maxims, which tended to be based on folk pedagogy and cultural norms connected with traditional modes of instruction, tended to limit the ability of the teachers in this study to apply theoretical and strategic knowledge, and use reflection, analogical reasoning and informed judgment in making instructional decisions concerned with the assessment of students. Belief systems held by teachers about how students learn and about their abilities, dispositions, and motivation also had a significant impact on the tendency to implement learner-centered instruction including the use of formative assessment. At times, constructivist beliefs about learning facilitated the use of formative assessment and instructivist beliefs and approaches to teaching and learning constrained it. Additionally, one teacher struggled with overcoming her experiences as a learner in traditional science classrooms as she attempted to transform her espoused theories into reform-based practices.

Expectations, habits and dispositions of students existed that served as external contextual elements that constrained the use of formative assessment for one teacher. However the most influential external contextual element that influenced the teachers' PPATs and formative assessment practices was the pressure they felt to "cover" all of the curriculum so as to prepare students for the end-of-year, high stakes exam. There was clear evidence of tendencies to "teach to the test" by teachers in this study. The perception that the test required low-level, factual recall influenced their instructional decisions and practices, which resulted in an emphasis on summative assessment and little emphasis and instructional time for formative assessment practices.



5) To what extent does formative assessment affect student achievement and motivation in the typical science classroom?

There was a clear difference in student achievement and motivation to learn in the class where formative assessment was practiced in an ongoing manner compared to classes where formative assessment was used less frequently. Students in the class where formative assessment was used on a regular basis scored higher in all but one sub-category on the achievement test. Scores on two of the ten sub-categories saw a statistically significant difference. Student motivation was also significantly higher in the high-frequency formative assessment class compared to the low-frequency formative assessment class. The medium-frequency formative assessment class saw student motivation results in between the two.

### Discussion

The purpose of this study was to address several unanswered questions in the existing literature and add to the growing body of knowledge related to formative assessment practices of classroom teachers. In particular, I sought to examine the type, frequency and use of formative assessment by science teachers and contextual factors that influenced their use, and the impact of formative assessment on student achievement and motivation. This summary addresses findings from my study that extend existing research findings and thinking regarding formative assessment.

## Student Motivation

“Despite the central role attributed to student action and self-assessment very little is known about student perceptions and experiences of everyday classroom formative assessment” (B. Cowie, 2005). Research has clearly established that the use of formative assessment increases student achievement, and that student achievement (in general terms, but not necessarily in the formative assessment research) is positively correlated to student motivation (and vice versa). However, research to date has not directly examined the relationship between teacher formative assessment practices and students’ perception of their control over, and interest in, learning; two sub-components of intrinsic motivation.

Research by Brown and Hirschfield (2008) that explored students’ perceptions related to formative assessment found that student perceptions about assessment were directly related to achievement. They concluded that when students *perceive* of assessment as a means of taking responsibility for their own learning, enhanced educational outcomes are more likely, but the conclusions of their research study were not informed by data collected through classroom observations of practice. This research study extended their findings to include practice.

One of the key outcomes of this study was the evidence from the student surveys that demonstrated that students engaged in the learning process with a teacher, who helped them take responsibility for their own learning through formative assessment practices, were more interested in learning and felt they had a measure of control over their learning. Data from this research study also revealed a direct, positive relationship between classroom formative assessment practices, student motivation and student

achievement. Crooks (1988) contended that interest and motivation should be regarded as at “least as important as cognitive outcomes” (p. 460).

### Contextual Elements

Researchers (Jones, 1997; Lave, 1991, 1993) have identified many external contextual elements that influence daily curricular decisions made by teachers such as those related to the emphasis given national or state standards and related high-stakes tests, which have the potential to shift the emphasis away from formative to summative assessment. Smith and Southerland (2007) examined how teacher beliefs about learning and internally constructed contextual elements influenced their tendency to embrace reform practices including inquiry-based learning. They found that even though the two teachers in their study “were familiar with and reacted to specific tools of science education reform, these tools failed to encourage and support the kind of instruction envisioned by reformers” (p. 415). They stated that one reason for the lack of implementation was the teachers’ beliefs about what it meant to teach and learn science. One teacher in their study believed that inquiry-based learning was “just a fad” and that students learned best through direct instruction, and she used the end-of-year mandated test to justify her instructivist approach to teaching (claiming that the test called for rote-memorization). The other teacher believed that students construct knowledge and should learn through inquiry. The tenets of reform were congruent with her beliefs about science teaching and learning (p.410).

The present study found similar results related to beliefs about how students learn and what it means to teach and learn science. Constructivist beliefs about learning held

by teachers facilitated the use of formative assessment and instructivist beliefs and approaches to teaching and learning constrained it. However, this study found that, in addition to beliefs about learners and learning, forms of knowledge held by teachers served as a filter through which espoused beliefs were transformed into practice. In particular, although Monica held the belief that students construct knowledge through inquiry and that students should learn with understanding, her lack of appropriate theoretical or strategic knowledge served as a barrier to putting her beliefs into practice.

Another contextual element that was identified by this study that has received little attention in the literature was the tendency of students to adhere to established customs and norms of the school rather than fully take advantage of opportunities to partner with teachers in the learning process. Phoebe found that this contextual element negatively affected her ability to assess student understanding of concepts, as students worried more about grades than learning.

### Diagnostic Tools

During this research study, several diagnostic tools were developed and used to gather or analyze research data. These tools included a formative assessment survey (Appendix C), a learner-centered classroom interaction analysis (LCIA) coding system (Appendix H), an assessment development model (Figure 1.2), and a student motivation survey (Appendix L).

### Formative Assessment Survey

The formative assessment survey served as a useful tool to gather self-reported data regarding teachers' formative assessment practices including their instructional response to students' needs, their classroom dialogue and questioning strategies, the type of written feedback they provided students, and their involvement of students in the learning and assessing process. Internal consistency estimates of reliability were computed for each category and expressed as Cronbach's alpha at .779, .812, .609 and .610 respectively. The instrument has the potential to provide other researchers a means for collecting data as they investigate formative assessment practices and related questions. However, this instrument could be improved by adjusting categories three and four to increase their estimates of reliability. Additionally, on the survey, a lower value represented a higher use of formative assessment. For future studies, those values should be reversed to avoid confusion. A higher value on the scale should represent a higher use of formative assessment.

### LCIA Coding System

The LCIA coding system piloted during this study had not been validated through other research studies. However, it proved to be informative as I attempted to examine communication patterns among different teachers within various contexts. It has the potential to assist other researchers as they attempt to characterize and distinguish teacher and student communication patterns in learner- and teacher-centered classrooms. It also could be used as an instructional or reflective tool for in-service and pre-service teachers as they strive to understand and critique their own classroom practices.

### Assessment Development Model

The assessment development model modified from Cornett's curriculum development model served as a useful framework for analysis of the dynamic interactions between PPATs and contextual elements, and their impact on the purpose, planning, implementation and reflection on assessment practices. This model could be used in other research studies as a vehicle for within-case analysis of these components or in action research projects (Cornett, 2001) that help teachers analyze the impact of their PPATs on assessment opportunities for students.

### Student Motivation Survey

The student motivation survey provided valuable insight into the effect of teacher practices on student interest in the class and their perceived control over their own learning. Too often, student perceptions are overlooked during attempts at educational reform, and "this apparent lack of concern with student responses to changes in policy and practice constitutes them as compliant beneficiaries of change" which is not necessarily the case (Cowie, 2005, p. 200). This student motivation survey provides a tool for researchers for use in investigating assessment practices in context of actual classroom practices and the impact that those practices have on students. On this survey, internal estimates of reliability were computed for each sub-scale of motivation (interest and perceived control) and Cronbach's alpha was .915 and .802, respectively, supporting the reliability of the instrument.

### Future Research

During this research study, questions emerged that warrant further examination. In particular, what effect does classroom formative assessment have on students' beliefs about their own learning? If students perceive intelligence as fixed, can effective formative assessment practices spur a conceptual change about intelligence as flexible and changeable? Crooks (2005) contended that very few studies have investigated formative assessment from the students' perspective. This study provided evidence that students who were immersed in a learner-centered classroom where formative assessment was the norm felt they had a higher degree of control of their own learning. Does this mean that they perceived their intelligence as flexible? Research by Dweck (2007) revealed that there are students who believe that their intelligence is fixed, focus on learning tasks that confirm their beliefs about how intelligent they are, or avoid tasks that do not. Students who believe that their intelligence is flexible "take on challenges and stick to them" (p. 34, 35). It appears that they feel that they have a measure of control over their own learning. What metacognitive processes within formative assessment enable students to develop conceptual understanding of intelligence as flexible? The idea of intelligence as flexible rather than a fixed entity has far-reaching and long-term implications for students as life-long learners in their academic and personal lives.

Secondly, what factors influence a teacher's ability, tendency or desire to use practice-centered inquiry to improve instruction? Phoebe demonstrated this tendency throughout the study and as a result, taught students in a manner contrary to the educational norms of her school. During her interview, she stated that she assessed

differently now than she did when she first started teaching. I asked her what prompted the change and she responded:

Exposure to what is good teaching. And just seeing that there were other things out there. But I've always changed. I mean, I am never, ever, ever, satisfied with what I do...you know I think that once you get comfortable, that's a dangerous place to be in education...you can't just use the same methods...they're different kids, we're at a different place, there are new developments...you can't just do the same thing. Exposure to what is good, and trial and error...that works.

How can we engender this attitude and approach to education in pre-service and in-service teachers in our efforts of reform?

#### Limitations of the Study

There are many factors that influence teacher decisions with regard to instruction and assessment in the classroom. In addition to factors examined in this research study, teacher efficacy has a significant impact on instructional decisions. Self-efficacy as defined by Bandura's social cognitive theory is a person's perception of their own competence in dealing with their environment (Miller, 2002). This study did not address the role of teacher efficacy as a factor having the potential to constrain or facilitate the use of formative assessment by classroom teachers. It may be possible that teachers with errant beliefs about how students learn maintained high self-efficacy, and did not feel compelled to reflect on their own practice and implement different teaching and assessing strategies. Because teacher self-efficacy is one of the "strongest predictors of human motivation and behavior" (Pajares, 1992, p. 329) it seems important that future research examine this variable and its impact on the use of formative assessment.



Secondly, this study found that a learner-centered approach to instruction that included formative assessment had a direct effect on student achievement. However, there are many factors which impact student achievement that were not addressed in this study including the knowledge level of the teacher. Duschl, et al. (2007) reported that student achievement in science is positively correlated to the number of college level science courses a teacher has taken and the number of degrees they hold. “Research findings generally support the notion that higher levels of teacher subject matter knowledge contribute to higher student achievement” (Duschl, 2007). In this study, Phoebe was completing her Master’s Degree in Multidisciplinary Science, which may have influenced the quality of instruction and therefore student achievement.

#### Recommendations for Professional Development

Popham (2008) contended that formative assessment has the potential to be *transformative* in that “classroom assessment can fundamentally transform the way a teacher teaches” (p. vii). For formative assessment practices (or any reform practices for that matter) to become transformative, teachers must be involved in professional development opportunities that provide the structure, knowledge, and experiences to help them change their beliefs, increase their knowledge and alter their habits (Loucks-Horsley, Love, Stiles, Mundry, & Hewson, 2003). Teachers are agents of change that have the potential to transform learning opportunities for students but for many teachers their personal theories about assessment must change. These theories are multilayered, shaped by experiences, forms of knowledge, and beliefs, and influenced by contexts that often present conflicting messages to the teacher. For science teachers, changing

instruction may be particularly difficult due to their experiences as a science student themselves. Most science classes traditionally have focused heavily on “memorizing facts, without emphasizing deeper conceptual understanding of subject matter and inquiry as a means of learning science” (Smith & Southerland, 2007). Additionally state mandated exit exams have the potential to perpetuate the habits embedded in traditional instruction rather than those fostered by inquiry learning.

However, reform can occur through effective professional development that is transformative and empowers the teachers as agents of change. Loucks-Horsley, et al. (2003) contended that there are five requirements for providing a transformative learning experience:

1. Create a high level of cognitive dissonance to upset the balance between the teachers’ beliefs and practices and new information or experiences about students, the content, or learning.
2. Provide sufficient time, structure and support for teachers to think through the dissonance experienced.
3. Embed the dissonance creating and resolving activities in teachers’ situations and practices.
4. Enable teachers to develop a new repertoire of practices that fits with their new understanding.
5. Engage teachers in a continuous process of improvement.

Without effective systems of professional development that lead to transformative assessment practices, the potential to increase student achievement through such practices

will remain marginal. The five requirements outlined by Loucks-Horsley, et al. describe a system that requires much more than the common method of one-shot professional development workshops that introduce teachers to strategies that they may or may not embrace. Transformative learning requires what Thompson and Goe (2006) described as Teacher Learning Communities that address both content (not subject matter, but rather pedagogical content) and process aspects of teacher growth (p. 2) wherein teachers are immersed in constructing knowledge about effective teaching.

In particular, they recommended that professional development should focus on the day-to-day instructional practices of teachers to include use of five key strategies of formative assessment:

1. Engineering effective classroom discussions, questions, and learning tasks
2. Clarifying and sharing learning intentions and criteria for success
3. Providing feedback that moves learners forward
4. Activating students as the owners of their own learning
5. Activating students as instructional resources for one another

This study found that teachers lack crucial theoretical and strategic knowledge related to assessment, but expressed some willingness to become more informed about formative assessment practices and more adept in their use. Clandinin and Connelly (1997) contended that “to more closely relate ideas about teaching and learning with the practice of teaching and learning, we need to be concerned with what it is that teachers know and with the knowledge environment in which they work” (p. 674). Sustained professional development that addresses the five key strategies in a manner described by

Loucks-Horsley has the potential to develop theoretical and strategic knowledge necessary to overcome external contextual elements, such as high-stakes testing, that is required to implement formative assessment that ultimately has the potential to transform education and student learning.

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## Appendix A

### Diary Curriculum Map 2007-2008

XXXXX Independent School District

XXX / (D ) Biology I Pre-AP / Grade 9 (XXXX High School)

	<u>Essential Questions</u>	<u>Content</u>	<u>Skills</u>	<u>Assessment</u>	<u>Character &amp; Modification</u>	<u>Reflection</u>	<u>Resources / Activities</u>
<p><b>Nature of Science</b>              (Week 1, 36 Weeks)</p>	<p>How does the Nature of Science relate to your life?</p>	<p>1. Lab Safety            a. Equipment            b. Safety Symbols             2. Experimental Procedures            a. Scientific Method            b. Unit conversions, measurement, accuracy vs. precision             3. Scientific impact            a. Evaluation of scientific explanations,            b. Promotional claims            c. Research            d. Careers            e. History</p>	<p>1. Identify and adhere to lab safety rules and symbols            Select and use appropriate lab equipment            Plan appropriate use for lab resources            2. Develop scientific procedures Design experiments            Organize and present data            Develop and present valid conclusions            3. Evaluate scientific ideas            Summarize scientific career opportunities            Identify scientific historical contributions</p>	<p>TAKS Bellringers            Volume Lab Participation            Reading Graduated Cylinders WS            Vitruvian Man Length Lab            Lab Safety Quiz (11 M/C Q's)            Estimerics Game            Volume WS            Thinking Like a Scientist I - Scientific Processes WS            Fortune Telling Fish Lab            Thinking Like a Scientist II - Scientific Processes WS            Training Termites Lab            Thinking Like a Scientist III - Scientific Processes WS            Scientific Processes &amp; Metrics Test (20 M/C Q's)            Microscope Lab - Structures and Functions, Wet (Enormous E) and Dry            Microscope Lab - Roots and Stems            Microscope Lab - Stomata Lab            Plant Reproduction/Adaptations            Nitrogen, Phosphorous, and</p>	<p><input type="checkbox"/> <b>Classroom Work</b>            (Classroom expectations are set up according to the pillars of character.)  <input type="checkbox"/> <b>Modification Opportunity</b> (As a Pre AP supplement, the students designed thier own labs to test "What Makes Fortune Telling Fish Work?" and "Do Termites Respond to Scent or Color?")  <input type="checkbox"/> <b>Modification Opportunity</b> (Pre AP students spend time working on metric conversions through dimensional analysis in order to better prepare them to directly enter Pre AP Chemistry)  <input type="checkbox"/> <b>Modification Opportunity</b> (Students are keeping composition notebooks and utilizing them for multiple purposes.)</p>	<p>Remember to use new power-point over "What is Science?" with information from "The Science Teacher" magazine             I showed a safety video my kids made years ago b/c I have trouble finding an up to date video that pertains primarily to Biology. Problem is it is funny ... and I don't want them to think safety is funny. Jones has some GT kids who are looking at making a new one! Woo Hoo.             I had the kids explain what would happen if we didn't follow the safety rules this year, it worked but they always go for the worst case scenario ... "You could DIE." I'm just not sure what else to do!             For equipment, the students had to circle the pictures of the equipment that they didn't know the function of.</p>	<p>Equipment and Safety Symbols handout taken from multiple sources            Safety Video            Lab &amp; safety equipment handout            *Students are assigned safety rules and explained what would happen if we didn't follow the rules.            *Students identified equipment whose function they did not know and we discussed those items as a class            Making Observations            *Peanut activity - kids describe their peanuts in their journals and then must have a neighbor find the peanut based on their observation. They all do a poor job first off, then I show them some examples of journals ... da Vinci and Lewis and Clark. The kids then try again using all of their senses (except taste) and they do better the second</p>

<i>Essential Questions</i>	<i>Content</i>	<i>Skills</i>	<i>Assessment</i>	<i>Character &amp; Modification</i>	<i>Reflection</i>	<i>Resources / Activities</i>
		Identify scientific historical contributions	Potassium Levels Lab		<p>It took a lot less time, and I think it was beneficial. (?)</p> <p>Making the students select the equipment necessary for the volume lab was awesome. I think, from the conversations I was hearing, that they learned a lot. The water displacement part is pretty lame, and they all pretty much knew about it.</p> <p>I've already revamped the Vitruvian Man Lab and made it more leading so the kids had no doubt as to what I wanted them to say. I don't like doing too much leading, but they aren't very confident in their own ability to analyze data.</p> <p>I need to redo the Volume WS and make it where there is no wiggle room for</p>	<p>time around. Volume Lab *The students had to select their own equipment on this one, and they only got one shot. Scientific Method Power Point Notes Vitruvian Man Length Lab Metrics Notes and foldable Dimensional Analysis Notes &amp; practice on white boards Thinking Like a Scientist I Fortune Teller Fish Lab Metrics Quiz Thinking Like a Scientist II Training Termites Lab Thinking Like a Scientist III Scientific Processes Test Microscope Lab - Structures and Functions, Wet (Enormous E) and Dry mount Microscope Lab - Roots and Stems Microscope Lab - Stomata Lab Plant Reproduction/Adaptations Lab Nitrogen, Phosphorous, and Potassium Levels Lab</p>



07-08 Lab Safety Rules

**Appendix B**  
**Institutional Review Board for the Protection of Human Subject**



December 17, 2007

Gerald Skoog  
Curriculum & Instruction  
Mail Stop: 1071

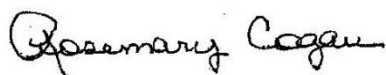
Regarding: 501069 Formative Assessment: Patterns, Contextual Influences, and Impact on Student Achievement and Attitudes in Science

Dr. Gerald Skoog:

The Texas Tech University Protection of Human Subjects Committee has approved your proposal referenced above. The approval is effective from December 17, 2007 through November 30, 2008. This expiration date must appear on all of your consent documents.

You will be reminded of the pending expiration approximately eight weeks prior to November 30, 2008 and asked to give updated information about the project. If you request an extension, the proposal on file and the information you provide will be routed for continuing review.

Sincerely,

A handwritten signature in cursive script that reads "Rosemary Cogan".

Rosemary Cogan, Ph.D., ABPP  
Protection of Human Subjects Committee

## Appendix C Science Teacher Survey

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**Purpose:** The purpose of this survey is to gather information about teacher practices in the science classroom. The data gathered will be used as a basis for further research. Thank you for your assistance and input.

**Private and voluntary participation:** No actual names will be used in any report. The results of the survey may lead to a request for further study of your classroom practices, beliefs, etc. Participation will be completely voluntary.

**Survey conducted by:** Cathy Box, Texas Tech University doctoral candidate, College of Education under the supervision of Dr. Gerald Skoog.

To grant permission for continued contact, please provide the following:

Name: \_\_\_\_\_ E-mail address \_\_\_\_\_

School: \_\_\_\_\_ School phone: \_\_\_\_\_

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### Background and Demographics

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1. What grade level(s) do you teach?

\_\_\_\_\_

2. What specific discipline(s) (for example, IPC, biology, chemistry, etc.) do you teach? (if applicable)

\_\_\_\_\_

3. How many years have you taught the science disciplines listed above?

\_\_\_\_\_

4. What is your age and gender?

\_\_\_\_\_

5. What subject(s) and level(s) are you certified to teach?

\_\_\_\_\_

**Classroom Practices** – Please indicate on a scale of 1 – 5 the frequency of your use of the following strategies in your classroom. Circle the best answer.

**1 – Often    2 – Frequently    3 – Sometimes    4 – Rarely    5 – Never**

<b>In my classroom, I...:</b>	<b>Often</b>	<b>Sometimes</b>	<b>Never</b>		
6. Use cooperative learning groups	1	2	3	4	5
7. Have students develop concept maps	1	2	3	4	5
8. Encourage competition in the classroom	1	2	3	4	5
9. Guide students to brainstorm and list ideas on the board	1	2	3	4	5
10. Use peer assessment	1	2	3	4	5
11. Ask students to generate test questions	1	2	3	4	5
12. Use numerical grades on student work	1	2	3	4	5
13. Ask open-ended questions including <i>how</i> and <i>why</i>	1	2	3	4	5
14. Ask students to write out their learning goals	1	2	3	4	5
15. Use a KWL	1	2	3	4	5
16. Use hands-on activities	1	2	3	4	5
17. Use assessment data to plan and adjust instruction	1	2	3	4	5
18. Test definitions of vocabulary words	1	2	3	4	5
19. Involve students in developing rubrics	1	2	3	4	5
20. Allow students to redo their work	1	2	3	4	5
21. Use benchmark tests before instruction	1	2	3	4	5
22. Make written comments on returned papers instead of numerical grades	1	2	3	4	5
23. Involve students in developing models	1	2	3	4	5
24. Use a rubric to assess learning	1	2	3	4	5
25. Have students present research findings in a poster or PowerPoint presentation	1	2	3	4	5
26. Use portfolios as a measure of assessment	1	2	3	4	5
27. Provide a check-sheet or other document for self assessment	1	2	3	4	5
28. Have students exchange and grade papers	1	2	3	4	5
29. Provide opportunities for students to reflect on their work (in writing)	1	2	3	4	5
30. Use a quiz before instruction to expose misconceptions	1	2	3	4	5
31. Provide written feedback with advice on improvement	1	2	3	4	5
32. Provide a rubric to students after conducting an activity	1	2	3	4	5
33. Use the internet for research	1	2	3	4	5
34. Use journals or other methods to have students reflect on their learning	1	2	3	4	5
35. Use numerical grades combined with written comments on returned papers	1	2	3	4	5
36. Provide students with the rubrics or grading criteria prior to instruction and assessment	1	2	3	4	5
37. Alter direction of instruction based on student feedback	1	2	3	4	5



38. What factors and influences guide your development and implementation of lesson plans? Are your plans detailed or general? What are some factors that may cause you to deviate from your plans? (use the backside of this sheet if additional space is needed)

39. If you use concept maps, describe how you use them and for what purpose(s).

40. If you use benchmark tests, what is your primary purpose or goal in doing so? Are they effective in achieving your purpose or goal?

41. In thinking about a lesson you taught last year where you perceived student learning was at an optimum level, what strategy or strategies did you use that you think contributed to the effectiveness of the lesson? Why do you think the strategy or strategies were effective?

**Appendix D:  
Teacher Consent Form**

**Formative Assessment: Patterns, Contextual Influences, and Impact on Student Achievement and Attitudes in Science**

You are invited to participate in the research study being conducted at Martin ISD. My name is Cathy Box and I am a Ph.D. candidate at Texas Tech University, working under the direction of Dr. Gerald Skoog, Professor and Dean Emeritus of the College of Education. The goal of this research project is to investigate how classroom assessment practices affect student achievement and attitudes toward learning. We are asking your permission to be included in this study. The data obtained from this study will be collected during the 2007-2008 school year.

You will not be asked to change your regular classroom practice in any way. There are no risks involved for you or your students. One class will be videotaped for the duration of one unit. These video tapes will be used to supplement and clarify my observations. The videotapes will not be used for any purpose other than this research. You will have access to the videotapes at any time. At the conclusion of the unit, you will be asked to take complete a questionnaire which will take approximately 30 minutes to complete. I may also request copies of lesson plans, curriculum maps or other supporting documentation that you may provide at your discretion.

If you agree to be part of this study, your normal classroom practice will be analyzed as part of the research data. Additionally, you will be interviewed from time to time, either face to face or via email. You do not have to answer every question during the interview. Audio and/or video tapes made during these interviews will be coded so that no personally identifying information will be given, they will be kept in a secure place, and they will be heard or viewed only for research purposes by me or my associates. At the conclusion of the study the tapes will be retained in a locked cabinet by me for five years. Your students' scores on benchmark exams and six-weeks exams will be included as part of the study, as well as information about your students attitudes about learning.

Any information that is obtained in connection with this study will remain confidential and will only be disclosed with your permission. Your responses will not be linked to your name in any written or verbal report of this research project. You will be assigned a pseudonym of your choice.

Your decision whether or not to participate in this study will not affect your present or future relationship with Texas Tech University. There are no known risks as a result of participation.

If you have any questions about the study, please contact me, Cathy Box, at 806-561-4538 or at [cathy.box@ttu.edu](mailto:cathy.box@ttu.edu). I will answer any questions you have about the study. For questions about your rights as a subject or about injuries caused by this research, contact the Texas Tech University Institutional Review Board for the Protection of Human

Subjects, Office of Research Services, Texas Tech University, Lubbock, Texas 79409. Or you can call 806-742-3884. You will be given a copy of this consent form for your records.

Your signature below indicates that you have read the information provided above and have decided to participate in the study. If you later decide that you wish to withdraw your permission, simply tell me by via telephone (561-5021) or email (cathy.box@ttu.edu). You may discontinue participation at any time.

\_\_\_\_\_  
Name

\_\_\_\_\_  
Signature

\_\_\_\_\_  
Date

\_\_\_\_\_  
Investigator: Cathy Box  
Cathy.box@ttu.edu

\_\_\_\_\_  
Date

We may wish to present some of the information we gain in this study to academic conventions or as demonstrations in classrooms. Please sign below if you consent to letting us do so. You will remain anonymous.

I hereby give my permission for the information gained in this research to be used for educational purposes.

\_\_\_\_\_  
Signature

\_\_\_\_\_  
Date

**This consent form is not valid after May 25, 2008.**

**Appendix E:  
Administrator Consent Form**

**Formative Assessment: Patterns, Contextual Influences, and Impact on Student  
Achievement and Attitudes in Science**

You are invited to participate in the research study being conducted at Martin ISD. My name is Cathy Box and I am a Ph.D. candidate at Texas Tech University, working under the direction of Dr. Gerald Skoog, Professor and Dean Emeritus of the College of Education. The goal of this research project is to investigate how classroom assessment practices affect student achievement and attitudes toward learning. We are asking your permission to be included in this study. The data obtained from this study will be collected during the 2007-2008 school year.

You will be interviewed regarding assessment practices and programs that are in place at your school. There are no risks involved for you or your campus personnel. The interview will be audiotaped and last approximately 30 minutes. The interview will be conducted at a time and place of your choosing. I may request copies of campus plans or other supporting documentation that you may share at your discretion.

You do not have to answer every question during the interview. Audiotapes made during the interview will be coded so that no personally identifying information will be given, they will be kept in a secure place, and they will be heard or viewed only for research purposes by me or my associates. At the conclusion of the study the tapes will be retained in a locked cabinet by me for five years.

Any information that is obtained in connection with this study will remain confidential and will only be disclosed with your permission. Your responses will not be linked to your name in any written or verbal report of this research project. You will be assigned a pseudonym of your choice.

Your decision whether or not to participate in this study will not affect your present or future relationship with Texas Tech University. There are no known risks as a result of participation.

If you have any questions about the study, please contact me, Cathy Box, at 806-561-4538 or at [cathy.box@ttu.edu](mailto:cathy.box@ttu.edu). I will answer any questions you have about the study. For questions about your rights as a subject or about injuries caused by this research, contact the Texas Tech University Institutional Review Board for the Protection of Human Subjects, Office of Research Services, Texas Tech University, Lubbock, Texas 79409. Or you can call 806-742-3884. You will be given a copy of this consent form for your records.

Your signature below indicates that you have read the information provided above and have decided to participate in the study. If you later decide that you wish to withdraw

your permission, simply tell me by via telephone (561-5021) or email (cathy.box@ttu.edu). You may discontinue participation at any time.

\_\_\_\_\_  
Name

\_\_\_\_\_  
Signature

\_\_\_\_\_  
Date

\_\_\_\_\_  
Investigator: Cathy Box  
Cathy.box@ttu.edu

\_\_\_\_\_  
Date

We may wish to present some of the information we gain in this study to academic conventions or as demonstrations in classrooms. Please sign below if you consent to letting us do so. You will remain anonymous.

I hereby give my permission for the information gained in this research to be used for educational purposes.

\_\_\_\_\_  
Signature

\_\_\_\_\_  
Date

**This consent form is not valid after May 25, 2008.**

**Appendix F**  
**Student Assent Form**

I agree to participate in this research project. This study was explained to me by the researcher, Mrs. Box and my (mother/father/parents/guardians) said that I could be in it. The only people who will know what I say and do in the study will be the people in charge of the research project. All my information will be kept confidential.

I do not mind being videotaped in class and possibly interviewed in person by Mrs. Box. I understand that the interview will be with a small group of students and it will be audiotaped. If I decide to quit the study, all I have to do is tell the person in charge.

\_\_\_\_\_  
Signature of Student

\_\_\_\_\_  
Date

## **Appendix G: Parent Consent Form**

### **Formative Assessment: Patterns, Contextual Influences, and Impact on Student Achievement and Attitudes in Science**

Your son/daughter is invited to participate in the research study being conducted at Martin ISD. My name is Cathy Box and I am a Ph.D. candidate at Texas Tech University, working under the direction of Dr. Gerald Skoog, Professor and Dean Emeritus of the College of Education. The goal of this research project is to investigate how classroom assessment practices affect student achievement and attitudes toward learning. We are asking your permission to include your son/daughter in this study. The data obtained from this study will be collected during the 2007-2008 school year.

All students will participate in classroom learning experiences that are routinely provided them by their teacher. My research study will not change any classroom practices. There are no risks involved for your child. They will continue to pursue their normal academic activities regardless of their participation in the study. Their science class will be videotaped for the duration of three to six weeks. These video tapes will be used to supplement and clarify my observations. The videotapes will not be used for any purpose other than this research. If your child does not participate in this study, he/she will be seated in an area of the classroom that will not be videotaped.

If you allow your child to be a part of this study, his/her normal classroom participation will be analyzed as part of the research data. He/she will be asked to take a 20 minute attitude survey during their science class at a time that is convenient for the teacher and the students. Additionally, he/she may be invited to participate in a focus group that involves an interview with me during the normal school day. This interview will occur on campus, at a time that is convenient to the students but not during class time. The interview will last approximately 45 minutes. Students do not have to answer every question during the interview. Audiotapes made during these focus group meetings will be coded so that no personally identifying information will be given. They will be kept in a secure place, and they will be heard or viewed only for research purposes by me or my associates. At the conclusion of the study the tapes will be retained in a locked cabinet by me for five years. Your child's score on science benchmark and 6-weeks exams administered by MISD will be analyzed as part of this study. All students will be assigned a number which will be used in place of their name. Your child's name will never be used in any report.

Any information that is obtained in connection with this study (and that can be identified with your son/daughter) will remain confidential and will only be disclosed with your permission. His or her responses will not be linked to his or her name or your name in any written or verbal report of this research project.

Your decision whether or not to allow your son/daughter to participate will not affect your own or his/her present or future relationship with Texas Tech University. Also, students' grades will not be affected by your decision to allow him/her to participate in

this study. Your child's teacher will benefit from this study by helping them reflect on effective classroom practice. There are no known risks as a result of participation.

If you have any questions about the study, please contact me, Cathy Box, at 806-561-4538 or at [cathy.box@ttu.edu](mailto:cathy.box@ttu.edu). I will answer any questions you have about the study. For questions about your rights as a subject or about injuries caused by this research, contact the Texas Tech University Institutional Review Board for the Protection of Human Subjects, Office of Research Services, Texas Tech University, Lubbock, Texas 79409. Or you can call 806-742-3884. You will be given a copy of this consent form for your records.

You are making a decision about allowing your son/daughter to participate in this study. Your signature below indicates that you have read the information provided above and have decided to allow him or her to participate in the study. If you later decide that you wish to withdraw your permission for your son/daughter to participate in the study, simply tell me by via telephone (561-5021) or email ([cathy.box@ttu.edu](mailto:cathy.box@ttu.edu)). You may discontinue his or her participation at any time.

\_\_\_\_\_  
Name of son/daughter/or ward

\_\_\_\_\_  
Signature of Parent(s) or Legal Guardian

\_\_\_\_\_  
Date

\_\_\_\_\_  
Investigator: Cathy Box  
[Cathy.box@ttu.edu](mailto:Cathy.box@ttu.edu)

\_\_\_\_\_  
Date

We may wish to present some of the information we gain in this study to academic conventions or as demonstrations in classrooms. Please sign below if you consent to letting us do so. Your child will remain anonymous.

I hereby give my permission for the information gained in this research to be used for educational purposes.

\_\_\_\_\_  
Signature of Parent(s) or Legal Guardian

\_\_\_\_\_  
Date

**This consent form is not valid after May 25, 2008.**



**Appendix H**  
**Learner-Centered Interaction Analysis Coding System**

Silence	<p><b>0. Silence, confusion or transition</b></p> <ul style="list-style-type: none"> <li>• Pauses, short periods of silence, transition periods, laughter or confusion in which there is no communication or it cannot be understood by the observer</li> </ul>
Teacher talk	<p><b>1. Direct teacher talk</b></p> <ul style="list-style-type: none"> <li>• Direct transmission of teacher ideas or knowledge from teacher to student through verbal and graphic means. Includes directions for assignments, activities or classroom management purposes</li> </ul>
	<p><b>2. Asks convergent questions</b></p> <ul style="list-style-type: none"> <li>• Questions allow for a limited response</li> </ul>
	<p><b>3. Asks divergent questions</b></p> <ul style="list-style-type: none"> <li>• Questions allow for a number of answers</li> </ul>
	<p><b>4. Learner centered talk</b></p> <ul style="list-style-type: none"> <li>• Relates to or references prior learning experiences or knowledge; links content or explanations to existing knowledge</li> <li>• Clarifies, extends, incorporates or builds on students' ideas or comments</li> <li>• Asks students to respond to another student's answer, question or comment or to critique or extend their own answer or comment</li> <li>• Answers a student question by helping them build on what they know</li> <li>• Changes direction or content of talk in response to student question, comment or level of understanding</li> </ul>
	<p><b>5. Wait time</b></p> <ul style="list-style-type: none"> <li>• Waits a minimum of 3 seconds before or after a student response or question</li> </ul>
Student talk	<p><b>6. Student talk – response</b></p> <ul style="list-style-type: none"> <li>• Responds to teacher questions and directions (read the next paragraph, share the results you obtained, etc.)</li> </ul>
	<p><b>7. Student talk – initiation</b></p> <ul style="list-style-type: none"> <li>• Initiates talk without a teacher prompt.</li> <li>• Shares experiences, voices ideas, makes comments or contributes to the search for meaning or understanding.</li> <li>• Asks questions</li> <li>• Elaborates on another student's answer, question, comment or idea</li> <li>• Answers another student's question</li> </ul>

Category 0 – Silence, confusion or transition - This category depicts a period where there is no discernible discourse where there may be confusion, laughter, silence, and so on. This category would be used when students are writing, transitioning from place to place in the classroom, or waiting on the teacher during an interruption. This category is not used to denote “wait time” that occurs after a question or during the verbal interaction between teachers and students.

Category 1 – Direct teacher talk - Direct transmission of knowledge or ideas about content to student(s) through verbal and graphic means would be coded here. This category would be used when the teacher does not explicitly reveal or relate to what students know, believe, or understand about the topic. It would also be coded when a teacher answers a student question directly by simply telling them the answer, or if they answer their own question. If the teacher answers the student question with another question, it would be coded in category 2 or 3, depending on the type of question. If the teacher asks them to extend or elaborate on their answers or comments, it would be coded in category 4. This category also includes instances in which the teacher gives directives to students or provides them with information about assignments, activities or classroom management including matters concerned with student conduct and organization.

Category 2 – Convergent questions - In this category, the teacher asks questions that allow for only a limited number of responses. These questions may include factual recall questions or those that only require a yes/no answer. The teacher seeks and directs students toward the right answer. They may include verbs such as “define, list, recite, name,” and so on. Questions that can be answered dichotomously (i.e. yes/no, good/bad, tall/short) belong in this category.

Category 3 – Divergent questions - This category includes questions that allow a number of answers and wider responses. They are probing and open-ended and reveal where students are in their understanding. They promote higher level thinking and move beyond factual recall and require students to formulate answers that may require synthesis, comparisons, contrasts, extrapolation, or divergence. Sample questions that fit into this category could include:

- What is your view/opinion/idea about this?
- What evidence supports your claim?
- How did you arrive at that conclusion?
- How do these factors compare?

It does not include rhetorical questions or questions about classroom management issues. For example, if a teacher asks “what were you thinking?” to a student who made a poor decision to pass a note during class, the question would be placed in Category 1 since the intent of the question was to provide direction for student behavior.

Category 4 – Learner centered talk - In this category of teacher talk, the teacher purposefully elicits information from the students that reveals or relates to their knowledge, current level of understanding, interests, or experiences. They explicitly

relate their instruction to what students know or wonder. The teacher may incorporate student ideas into the discourse, and based on a student comment or question, ask the students to elaborate in order to extend or clarify their thinking. They may also ask students to elaborate on each other's comments or ideas. When it is evident that they change direction or content of talk in response to student question, comment or level of understanding, it would be coded here.

Category 5- Wait time - This category includes instances of silence (3 seconds minimum) when the teacher gives students time to formulate an answer. It also includes wait time provided by the teacher *after* a student answers a question that is meant to allow the student or other students to elaborate.

Category 6 – Student talk – response - In this category, the student talks in response to a question posed by the teacher or in response to a directive given by the teacher such as a request to read a passage or share results, information and so on.

Category 7 – Student talk – initiation - This category is coded when students voluntarily share ideas, make comments or contribute to the classroom discussion. Questions posed by students are placed in this category. When students voluntarily extend or elaborate on the ideas, comments, questions or answers of the teacher or of other students, or if they answer a question posed by another student during a whole-class conversation, it is coded in this category.

**Appendix I**  
**Comprehensive Dialogue Interaction Code for all Extended Classroom Dialogue**

<b>Teacher talk</b>	
1 Direct instruction	11 Relates content to current interest
2 Asks open ended questions	12 Asks for a show of hands to ascertain opinions
3 Asked closed questions	13 Promotes constructive argumentation
4 Asks students to raise hands w/ answer	14 Changes direction of instruction based on student response
5 Wait time for response	15 Uses a think/pair/share
6 Prompts student answer	16 Models reflective thinking
7 Asks another student same question	17 Elicits questions from students
8 Asks for elaboration on answer or question	18 Corrects incorrect answer
9 Verbally verifies student answer	19 Asks about prior learning experience
10 Incorporates student response into conversation	20 Talks about prior learning experiences from earlier instruction
<b>Student talk</b>	
1S Declines to answer – does not know answer	6S Initiates communication about knowledge
2S Answers question posed by teacher	7S Disagrees with or debates other student ideas
3S Elaborates on their own answer	8S Voices opinion
4S Elaborates on someone else's answer	9S Reads as prompted by teacher
5S Asks a question (about the learning)	10S Answers another student's question

## Appendix J Teacher Interviews

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*Researcher:* I'd like to visit with you about your beliefs and understandings about how students learn, and classroom assessment. First, we'll discuss some background information about you as a teacher.

---

First, let's talk about your decision to be a science teacher. Were there individuals and certain factors that influenced your decision to become a science teacher?

- Was there a teacher in high school or college that you think was exceptional? What made him/her an exceptional teacher?

---

How have your undergraduate and graduate experiences influenced the decisions you make as a teacher daily?

---

Would you describe a recent class session where you felt like you were effective in achieving your goals for that period? How about a recent class where you "bombed?"

---

Are you satisfied with the level of autonomy you have as a teacher in regard to what and how you teach?

---

Let's talk about classroom assessment. Are the assessment strategies and practices you tend to use now that are different than those you used earlier in your career? How? If they are different, what motivated the change?

---

Are the assessment strategies you use now providing you with what you'd like to know about what students know and are learning?

---

What's your view on how students learn? How do students learn or come to an understanding about important biology concepts? How do your views on how students learn influence assessment strategies?

---

Do you think that the results on the TAKS are an accurate indicator of what students have learned in your class?

---

There is much concern today about the level of student achievement in the sciences. What can you do as a teacher to facilitate and enhance student achievement?

---

Can you identify and describe a student in one of your classes that exemplifies what you consider to be a responsible and effective student?

---

## **Part II**

As part of my research, I am trying to learn about your “personal practice assessment theories” (PPATs). Personal practice assessment theories are your personal theories, beliefs, and practical knowledge of assessment, all of which are derived from your experiences. Would you list what you believe to be your personal theories about assessment?

Based on my observations of your classroom instruction, the data from the original survey that you took, and our conversations, I’ve developed a list of what I think represent your PPATs as well. I’d like to share them with you and combined with what you listed, come to a consensus about your personal practice assessment theories. When you look at my list, feel free to make adjustments as necessary. Feel free to eliminate or modify statements, so that we end up with a list of PPATs that conform to your thinking and guide your teaching.

Once that is done, please rank the list of theories from most important to least important.

---

## **Part III** (Used video prompting)

1. Do you recall why you...(assigned this project, used this strategy, gave this quiz, etc)? What were you trying to achieve?
2. Do you recall what prompted you to use this strategy?
3. What did you learn about the students?
4. What did you learn about the value of the activity itself?
5. Was it a good use of your time and that of the students’?
6. Have you or would you use it again? Why or why not

**Appendix K**  
**Cell Unit Test**

Please circle your answer

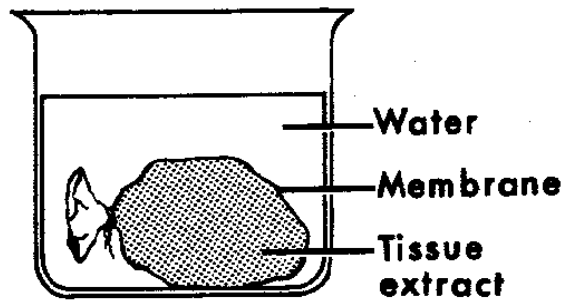
1. The nucleus stores most of a cell's
  - a. Ribosomes
  - b. DNA
  - c. Proteins
  - d. Amino acids
  
2. A biologist dilutes blood cells with water on a glass slide. The cells seem to explode as she views them through the microscope. This is probably because she
  - a. Used very salty water
  - b. Used dead cells
  - c. Added water too rapidly
  - d. Used distilled water
  
3. An analogy is a relationship between two pairs of words or phrases generally written in the following manner  $a : b :: c : d$ . The symbol  $:$  is read "is to," and the symbol  $::$  is read "as."

For example,  $cat : animal :: rose : plant$  is read "cat is to animal as rose is to plant." Complete the following analogy by providing the missing word or phrase.

Carbon dioxide, sunlight and water : photosynthesis :: \_\_\_\_\_ : aerobic respiration

- a. Autotroph
- b. Mitochondria and chloroplast
- c. Glucose and oxygen
- d. Glycolysis and Krebs cycle

4. The National Aeronautics and Space Agency's (NASA) command center in Houston, Texas directs space missions. Which part of a cell is analogous to this command center?
- a. Nucleolus
  - b. Cytoplasm
  - c. Nucleus
  - d. Cell membrane

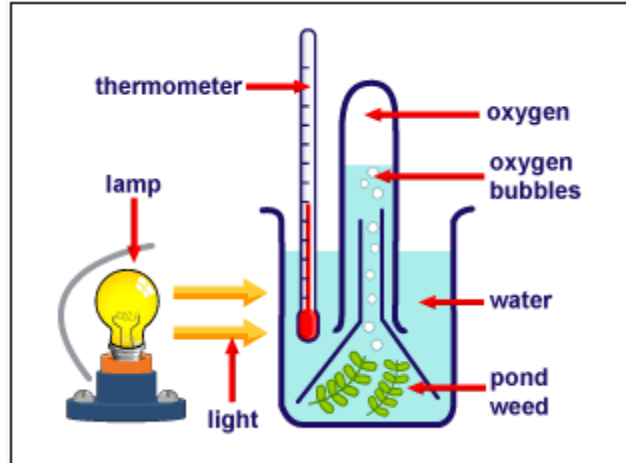


5. A bag with some plant tissue was placed in distilled water as shown above. The bag had a semi-permeable membrane. After leaving the bag in the water for a while, a test showed that an enzyme that digested starch was inside the bag, but not in the water outside the bag. Which of the following statements explains what happened?
- a. Enzyme molecules that digest starch were too large to pass through the membrane
  - b. The smallest molecules remained inside the membrane
  - c. The membrane absorbed the molecules
  - d. Water molecules were too large to pass through the membrane
6. Generally, prokaryotes differ from eukaryotes because of
- a. Size and simplicity
  - b. Rate of reproduction
  - c. Lack of membrane bound organelles
  - d. All of the above



7. An animal cell viewed in a microscope has a large number of ribosomes along the endoplasmic reticulum. What is a reasonable hypothesis for the cell's main function in the organism?
- It carries proteins
  - It makes proteins
  - It protects against disease
  - There is not enough information to determine a hypothesis
8. Which trait do both eukaryote and prokaryote cell types have?
- Both have a cell membrane
  - Both have membrane-bound organelles
  - Both have circular, naked DNA
  - Both have an organized nucleus
9. Because of the slow growth of her geraniums, a gardener decided to apply some fertilizer. The directions for fertilizer she bought recommended that two ounces be applied to the area with the plants. However, she used two pounds. Two weeks later all of the geraniums turned yellow and died. The most reasonable explanation for the plants' death would be
- Plant cells were damaged as water diffused out of the roots
  - She used the wrong kind of fertilizer
  - Plant cells were damaged as excess water diffused into the roots
  - She did not use enough fertilizer
10. Which part of an animal cell controls the materials moving into and out of the cell?
- Cell membrane
  - Endoplasmic reticulum
  - Nuclear membrane
  - Cytoplasm

11. What products given off during aerobic cellular respiration are used by plants for photosynthesis?
- Chlorophyll and stroma
  - Carbon dioxide and water
  - Oxygen and glucose
  - Sunlight and energy
12. The movement of water from an area of high concentration of water to an area of low concentration of water across a semi-permeable membrane is called
- Regulation
  - Osmosis
  - Stimulation
  - Facilitated diffusion
13. Which statement best describes how eukaryotic ribosomes compare to prokaryotic ribosomes?
- Proteins are made in eukaryotic ribosomes and packaged and stored in prokaryotic ribosomes.
  - Prokaryotes do not contain ribosomes
  - Eukaryotic and prokaryotic ribosomes function the same, but in eukaryotes, they may be either free floating or attached to endoplasmic reticulum
  - There is no difference between prokaryotic and eukaryotic ribosomes



[www.eou.edu/biology/](http://www.eou.edu/biology/)

Use the illustration above and the information that follows to answer question 14 and 15.

Biology students set up the experiment shown above. Each group varied the number of hours of light as shown below. The apparatus was kept in the dark the rest of the time.

- Group 1: 6 hours/day
- Group 2: 9 hours/day
- Group 3: 12 hours/day
- Group 4: 18 hours/day

14. Which group probably collected the *least* amount of oxygen?

- a. Group 1
- b. Group 2
- c. Group 3
- d. Group 4

15. Some students measured the pH of water containing *Elodea*, a common water plant. They wanted to determine how they could increase the pH of the water. The students knew that decreasing levels of carbon dioxide caused an increase in pH. What changes could students make in order to increase the pH of the water?

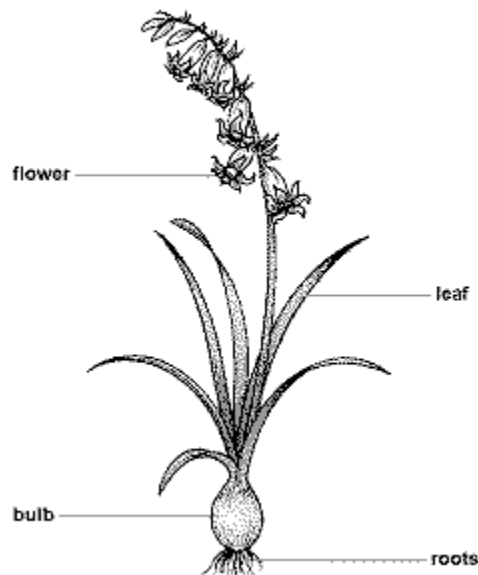
- a. Increase the plant's exposure to light so that the rate of photosynthesis increased
- b. Decrease the temperature of the water
- c. Reduce the plant's exposure to light so that the rate of photosynthesis decreased
- d. Decrease the number of *Elodea* plants

16. Aerobic cellular respiration produces

- a. Oxygen
- b. Carbon dioxide
- c. Glucose
- d. None of the above

17. Which response describes how a cell membrane helps maintain the health of the cell?

- a. The cell membrane causes the cell to have a definite shape
- b. The cell membrane contains genetic information of the cell
- c. The cell membrane regulates the movement of materials in and out of the cell
- d. The cell membrane lets molecules pass through regardless of their size



<http://www.ailwyn.schoolzone.co.uk>

18. In the diagram above, in which part of the plant does most of the photosynthesis take place?

- a. Flower
- b. Bulb
- c. Leaf
- d. Roots

Table 1

Container	Plant	Plant part	Light color	Temperature	Carbon dioxide after 2 days
A	Myrtle	Leaf	Red	60°	100 ml
B	Myrtle	Leaf	Red	80°	50 ml
C	Myrtle	Stem	Blue	70°	200 ml
D	Oak	Root	Blue	80°	300 ml
E	Oak	Leaf	Orange	80°	150 ml

Different plant parts were placed in five identical sealed containers. They were exposed to various colors of light and temperatures for an equal amount of time. The amount of carbon dioxide (CO<sub>2</sub>) present in each container at the beginning of the experiment was 250 ml. The amount of carbon dioxide in each container after two days was measured and recorded in Table 1.

Use the information from the paragraph above and from the data in Table 1 to answer the following questions. Assume that all other experimental conditions were identical in all five containers.

19. Based on the data in Table 1, which two containers should be compared to learn if temperature affects the amount of CO<sub>2</sub> used?
- A and B
  - A and E
  - B and D
  - A and C
20. In which container did the most photosynthesis occur?
- A
  - B
  - C
  - D
  - E

21. Which container gives evidence that the rate of respiration was higher than the rate of photosynthesis?
- a. A
  - b. B
  - c. C
  - d. D
  - e. E
22. Compare containers A and B. What is the independent variable in the design of the experiment?
- a. Temperature
  - b. Type of container
  - c. CO<sub>2</sub> present at the end
  - d. Plant part
23. To compare the amount of CO<sub>2</sub> used by an oak leaf to a myrtle leaf, you would need to change the
- a. Light color in container E to red
  - b. Light color in container A to orange
  - c. Length of the experiment to 3 days in all containers
  - d. Temperature in container A to 80°F

## Appendix L Student Survey

---

Do not write your name on this survey. All results will be kept confidential. Please circle the number between 1 (strongly disagree) and 7 (strongly agree) that most accurately describes your level of agreement with each statement.

1. I am very interested in learning biology.

1	2	3	4	5	6	7
Strongly disagree			Neutral	Strongly agree		

2. How much I participate in classroom activities in this class affects my grade.

1	2	3	4	5	6	7
Strongly disagree			Neutral	Strongly agree		

3. I have choices about how to learn biology concepts in this class.

1	2	3	4	5	6	7
Strongly disagree			Neutral	Strongly agree		

4. If extra credit assignments are offered in this class, I am willing to complete them to improve my grade.

1	2	3	4	5	6	7
Strongly disagree			Neutral	Strongly agree		

5. I complete biology assignments because I have to.

1	2	3	4	5	6	7
Strongly disagree			Neutral	Strongly agree		

6. This class holds my attention most of the time.

1	2	3	4	5	6	7
Strongly disagree			Neutral	Strongly agree		

7. If I try hard I can make good grades in this class.

1	2	3	4	5	6	7
Strongly disagree			Neutral	Strongly agree		

8. If I do not learn in this class it is the teacher's fault.

1	2	3	4	5	6	7
Strongly disagree			Neutral			Strongly agree

9. I can learn in this class if I choose to do so.

1	2	3	4	5	6	7
Strongly disagree			Neutral			Strongly agree

10. I make decisions that impact my grade in this class.

1	2	3	4	5	6	7
Strongly disagree			Neutral			Strongly agree

11. My success in this class has a lot to do with luck.

1	2	3	4	5	6	7
Strongly disagree			Neutral			Strongly agree

12. I can succeed in biology if I set realistic goals.

1	2	3	4	5	6	7
Strongly disagree			Neutral			Strongly agree

13. I do not have much influence over how much I learn in this class.

1	2	3	4	5	6	7
Strongly disagree			Neutral			Strongly agree

14. I think this class is boring.

1	2	3	4	5	6	7
Strongly disagree			Neutral			Strongly agree

15. My effort determines how much I learn in this class.

1	2	3	4	5	6	7
Strongly disagree			Neutral			Strongly agree

16. It is impossible for me to be successful in this class.

1	2	3	4	5	6	7
Strongly disagree			Neutral			Strongly agree



17. I know what I need to do to make good grades in this class.

1	2	3	4	5	6	7
Strongly disagree			Neutral		Strongly agree	

18. I look forward to coming to this class.

1	2	3	4	5	6	7
Strongly disagree			Neutral		Strongly agree	

## Appendix M Learning Questionnaire



Mrs. .



Grade .

For each assignment/activity listed:

Did you enjoy it? Do you even remember it?

Did it help you understand the concept more?

What changes would you make to the assignment?

Would you recommend that other students do the same assignment next year?

Give Mrs. Anderson an A, B, C or F

Red Eye for Snake Eye Demonstration (indicators)

I liked it but I would change the names so that it showed what they were in a festive way. **A**

Biomolecules Inductive/Notes (cutting out the pictures and grouping them)

the note help me but I really cant remember it as good as I can a lot of other stuff we do. **B-**

Biomolecules Lab (identifying proteins and carbohydrates)

I liked that! **A**

Enzyme Manipulative (foam pieces)

It helped me remember better and gave me a more visual way to see it.

**A**

Enzyme Lab (Toothpickase)

It worked for me.

**A**

Cell Game

I didnt like that because it required a lot of creativity and it didnt end up that good but Katie and Amy's game helped me. **B-**

Foldable Cell Notes

I use those all the time

**A**

Egg Lab (Osmosis)

I think of the egg Lab every time we talk about cell membrane and cell wall and other stuff like that. **A**

Chapter 6 & 7 Book Work

I think that was a good reinforcement and a good reminder.

**A**

Cell Simile

no good at all.

**F-**

Venn Diagram/Double Bubble

OK, I guess I used it to study but I really just copied from the book and I dont learn when I dont have to use my brain. **B-**

Surface Area/Volume Lab

not really, if I didnt have to do all that math to CONFUSE me.

**B-**

Cell Transport Foldable

I liked that it helped me alot.

**A**

Chapter 8 Bookwork HW and Design Your Own Lab

Very good, it was kinda like a reinforcement.

**A**

Notes on-line

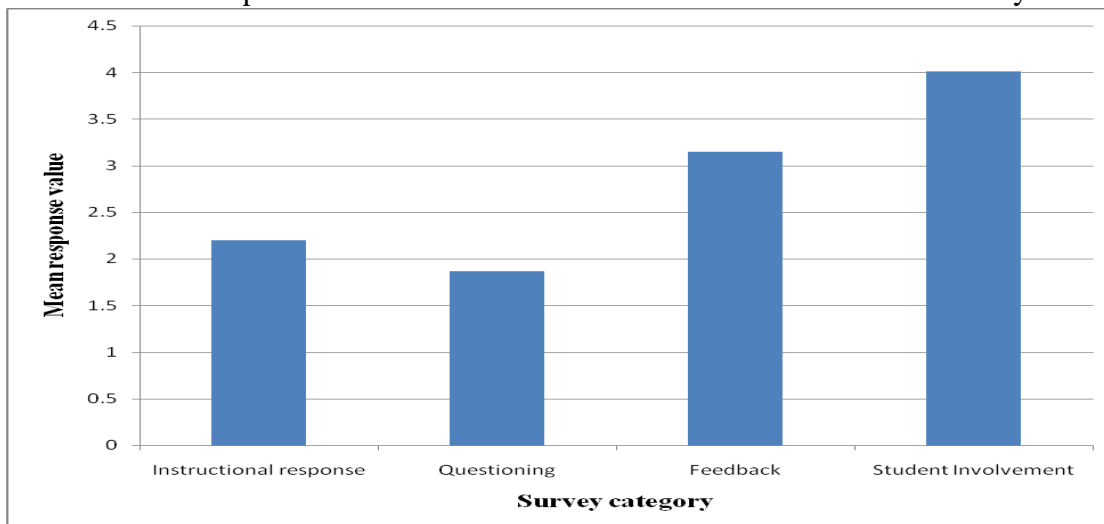
I dont remember to get notes and do stuff online. I dont learn well that way.

**F**

**Appendix N**  
**Formative Assessment Survey Results for MISD Science Teachers**

	<b>Mean</b>	<b>SD</b>
<b>Category 1 – Instructional Response <math>\alpha=.779</math></b>		
12. Use pre-test or survey results to help develop lesson plans	3.0952	1.26114
19. Change science lessons based on students' needs	1.8095	0.74960
21. Use assessment data to plan and adjust instruction	1.9048	.62488
36. Collect student data and use it to determine what to teach next	3.000	1.00000
48. Re-teach science concepts based on quiz or test results	2.1905	.92839
51. Change the pace of my instruction based on student feedback	1.7143	.71714
<b>Category mean</b>	<b>2.196</b>	
<b>Category 2 – Classroom Dialogue and Questioning Strategies <math>\alpha = .812</math></b>		
8. Use verbal questioning to determine students' understanding of science concepts	1.2381	.43644
16. Ask open ended questions including <i>why</i> and <i>how</i> in whole-class discussions	1.3571	.47809
25. Encourage students to elaborate on their answers in whole-class discussions	1.8095	.81358
30. Engage in extended dialogue with students to learn more about their thinking	2.0000	.89443
32. Ask students to justify an answer in whole-class discussions	1.8571	1.01419
41. Facilitate constructive argumentation in whole-class discussions about science concepts	2.5714	1.07571
43. Encourage students to verbally elaborate on the ideas of others in whole-class discussions	2.4286	1.16496
46. Encourage students to voice opinions, ideas or knowledge about scientific principles	1.6667	.65828
<b>Category mean</b>	<b>1.866</b>	
<b>Category 3 – Feedback <math>\alpha = .609</math></b>		
14. Use numerical grades only on student work	4.000	1.09545
29. Make written comments on returned papers <i>instead</i> of numerical grades	3.5238	1.07792
42. Provide written feedback with advice on improvement	2.8571	.96362
49. Use numerical grades combined with written comments on returned papers	2.1905	.87287
<b>Category mean</b>	<b>3.144</b>	
<b>Category 4 – Involving students in the learning/assessing process <math>\alpha = .610</math></b>		
13. Ask students to generate test questions	4.2857	.56061
17. Ask students to write out their learning goals	4.000	1.04881
24. Involve students in developing rubrics	4.0476	.92066
35. Use student annotated portfolios as a measure of assessment	4.3333	1.11056
37. Provide a check-sheet or other document for self-assessment	4.0000	1.04881
40. Provide opportunities for students to reflect on their work (in writing)	3.6667	1.15470
47. Use journals or other methods to have students reflect on their learning	3.7619	1.41084
<b>Category mean</b>	<b>4.0136</b>	

Mean responses of MISD teachers on the formative assessment survey



#### Analysis of rated statement results

Category 1 - Instructional response. These questions were designed to determine how teachers perceive that students' verbal feedback and/or written responses on quizzes or tests drives future instruction. A category mean of 2.196 indicated that teachers leaned toward formative assessment practices on the FA → traditional continuum. They *frequently* made use of information they gained about student learning to plan and guide instruction.

Category 2 – Classroom Dialogue and Questioning Strategies. These questions were designed to determine the extent to which teachers perceived that they elicited feedback from students that is revealing about their current level of understanding. It also reflects the degree of openness and freedom students have to express ideas, opinions and knowledge, and to actively participate in the learning process in a safe learning environment. With a category mean of 1.866, this category was the strongest for teachers on the FA → traditional scale. Teachers perceived that they ask higher level questions and lead students into discussions that promote openness and freedom of expression. Combining these results with category 1 results would imply that teachers feel they *frequently* elicit information and alter their instruction based on the feedback they obtain from students during classroom dialogue sessions.

Category 3 – Written feedback. These questions were designed to learn more about the teachers grading strategies and the extent to which they offered written feedback to their students instead of numerical grades. A category mean of 3.144 indicates that teachers fall in the middle of the FA → traditional scale. In order of frequency from most to least, teachers reported they 1) used numerical grades only 2) combined numerical grades with written comments 3) provided written feedback with

advice on improvement and 4) made written comments on returned papers instead of numerical grades.

Category 4 – Involving students in the learning/assessing process. These questions were designed to determine the extent to which teachers enabled students to have ownership in their own learning and assessing. This category was the weakest for the teachers in this survey. The category mean was 4.0126 indicating they rarely helped students set learning goals, reflect on their learning, make instructional or assessment decisions or self-assess.

Teachers were asked the following questions on the free response portion of the survey.

6. What factors and influences guide your development and implementation of lesson plans? Are your plans detailed or general? What are some factors that may cause you to deviate from your plans?
7. If you use concept maps, describe how you use them and for what purpose(s).
8. If you use benchmark tests, what is your primary purpose or goal in doing so? Are they effective in achieving your purpose or goal?
9. In thinking about a lesson you taught during the past few months where you perceived student learning was at an optimum level, what strategy or strategies did you use that you think contributed to the effectiveness of the lesson? Why do you think the strategy or strategies were effective?

#### Analysis of Short Answer Responses

The short answer questions were designed to gain insight into their teaching practices. Question 1 “What factors and influences guide your development and implementation of lesson plans? Are your plans detailed or general? What are some factors that may cause you to deviate from your plans?” revealed teachers’ approach to instructional decisions and planning. The willingness to alter the pace or direction of instruction is an important attribute of good formative assessment practices. When asked what guides the development and implementation of lesson plans, most teachers in this survey used the term “student” in their responses. For example, student needs, skill and prior knowledge, student mastery or understanding, etc. Secondly they mentioned district or state mandates such as the Texas Essential Knowledge and Skills (TEKS). Also frequently mentioned were consensus maps. These maps are developed collaboratively by the teachers at the beginning of the year and provide a scope and sequence that teachers are instructed to adhere to as much as possible. In fact, all MISD students are given periodic “checkpoint” tests in accordance with the consensus maps that assess student knowledge of science at particular points in time. This category could be grouped with the “mandates” category, since the district compels teachers to use the consensus map to guide their scope and sequence.

Once again, when asked what factors cause teachers to deviate from their lesson plans, most of the responses mentioned “students”. Student mastery, needs, interest, and so on. However, many teachers also mentioned outside factors that interfere with

instructional plans such as unexpected assemblies, pep rallies, benchmark tests, and absences due to extracurricular activities.

Question 2 asked teachers “If you use concept maps, describe how you use them and for what purpose(s).” None of the teachers indicated they used concept maps in a formative way i.e. to decide where students are in their learning. Most teachers used them for review or to organize their information. However, one teacher indicated that she uses the concept map at the beginning of instruction as students brainstorm ideas, and then students were directed to change them as they learned new concepts. This approach is consistent with formative assessment practices that promote making learning visible, but it is unclear if the teacher used the information to guide instruction.

The third question “If you use benchmark tests, what is your primary purpose or goal in doing so?” was designed to determine if they take advantage of pre-assessment scores to help guide their instruction. All students at MISD are required to take benchmark tests at the beginning of the year and those scores are disaggregated and provided to the teachers. Three teachers implied that they only give benchmarks because they have to and they really do not find them useful. The majority of the teachers however indicated that the benchmarks help them decide what TAKS objectives need more work for groups of students as well as individual students. Many teachers did not mention TAKS, but did mention that benchmarks help them monitor where the students are in their learning. A few teachers also mentioned the fact that benchmarks help students become familiar with the TAKS format and are useful to improve test-taking skills. Most teachers indicated that benchmarks were effective in achieving their goals.

The last question was “In thinking about a lesson you taught during the past few months where you perceived student learning was at an optimum level, what strategy or strategies did you use that you think contributed to the effectiveness of the lesson?” This question was fairly general and did not focus on any particular strategy, but rather allowed the teacher to express their ideas about successful teaching. Two teachers mentioned that they felt that continual feedback attributed to their students’ success – a practice consistent with formative assessment. The remainder of the responses reflected classroom practices such as hands-on work, group-work, differentiated instruction, etc.