

Student Perceptions of Formative Assessment in the Chemistry Classroom

A DISSERTATION  
SUBMITTED TO THE FACULTY OF THE GRADUATE SCHOOL  
OF THE UNIVERSITY OF MINNESOTA  
BY

Rachelle Ann Haroldson

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS  
FOR THE DEGREE OF  
DOCTOR OF PHILOSOPHY

Gillian Roehrig, Adviser

June, 2012

© Rachelle Ann Haroldson 2012

## Acknowledgements

I want to thank my advisor Dr. Gillian Roehrig for her constant support, especially for all of the feedback she provided on countless chapters, proposals, and drafts. Her steady encouragement kept me pursuing new and challenging goals.

I want to thank my dissertation committee. Thank you to Dr. Frances Lawrenz for giving me my first assistantship in graduate school and teaching me all I know about evaluation and efficiency.

Thank you to Dr. Mistilina Sato for two key meetings. The first meeting which provided the protocol for the “truth box.” The second meeting which provided guidance on how to structure my literature review. I appreciated her assistance in helping me to reach for the highest level of synthesis.

Thank you to Dr. Kyla Wahlstrom for telling me not to feel guilty and to remember to enjoy the little things. I will treasure her big hugs and be forever grateful that she offered to be on my committee.

I want to thank my dear friend Tara Burch for reading and editing my entire dissertation and for reminding me that sometimes it is necessary to go dig in the dirt with a good friend.

Thank you to my family and friends for all of their encouragement the past three years. For the dinners when I was too tired to feed myself, for the happy hours when I needed to socialize, for the Sunday sew afternoons to break up studying, and for the countless phone calls, emails, texts, and Facebook messages to keep me going when I needed the extra push.

Thank you to my sister, Alex, for making me laugh when life was getting too serious.

Thank you to my loving parents, Marilyn and Bruce, for always believing in me and enforcing a growth mindset through it all.

To my grandparents: Grandma Glo, Grandpa Herb, Grandpa Victor, and Grammy Helen. Wherever you are, I know you were watching out and cheering me on!

And finally, to my loving husband, Matt, for being so patient and kind.

## **Dedication**

First, this dissertation is dedicated to all of my chemistry students from the 2010-2011 academic year. We believed in each other to make this dissertation happen. They gave me the energy and passion to do this work. I gave them a voice.

This dissertation is also dedicated to my Grandma Sue. From the first days in graduate school to the final days of writing my dissertation she was always interested in what I was doing and encouraged me in the process. She also told me that while it is possible to fix a broken elbow, it is not possible to fix a broken head. Being true to her advice, I wear a helmet when biking and snowboarding.

## **Abstract**

Research on formative assessment has focused on the ways teachers implement and use formative assessment to check student understanding in order to guide their instruction. This study shifted emphasis away from teachers to look at how students use and perceive formative assessment in the science classroom. Four key strategies of formative assessment were implemented: feedback, questioning, self-assessment, and formative use of summative tests. Over the course of 15 weeks students experienced all of these strategies in three major chemistry units. During the class and at the end of the trimester interviews were conducted with students to look at their views regarding formative assessment and their learning. An inductive, emergent design was used to analyze students' responses in interviews and "truth box" vignettes. Common and unique themes emerged for each strategy of formative assessment.

Overall students found formative assessment to be beneficial to their learning because it provided clear expectations, prepared them for assessments, individualized the learning and informing them of their learning. Other benefits and uses that students reported included: being able to socialize, breaking large amounts of information into manageable pieces, having a second chance to learning, feeling good during the learning process, knowing what was wrong, developing a deeper understanding, focusing more, and having time for questions. Teachers and teacher educators need to be aware of how formative assessment strategies are perceived by students and recognize that the effectiveness of the strategies de-mystifies the learning experience, allows for a growth mindset in learning,

makes learning accessible to all students, and shows students how to close the gap in their learning.

## Table of Contents

<b>Acknowledgments</b> .....	i
<b>Dedication</b> .....	ii
<b>Abstract</b> .....	iii
<b>List of Tables</b> .....	x
<b>List of Figures</b> .....	xi
<b>Chapter I: Introduction</b> .....	1
Rationale .....	1
Statement of the Problem.....	2
Goals and Objectives .....	3
Potential Significance of the Study.....	3
Definitions.....	4
Overview of Following Chapters.....	4
<b>Chapter II: Review of the Literature</b> .....	6
Theoretical Framework.....	7
Formative Assessment .....	7
Summative Assessment .....	9
Evaluative Assessment.....	9
Theory of Formative Assessment .....	10
Closing the Gap.....	10
Inside the Black Box.....	11
Assessment for Student Learning .....	11

Motivation.....	12
Review of Literature .....	12
Key Strategies .....	13
Teachers and Formative Assessment.....	14
Providing Learning Goals.....	15
Questioning.....	15
Feedback.....	16
Formative Use of Summative Assessments.....	17
Formative Assessment Continuum .....	17
Students and Formative Assessment.....	18
Understanding Learning Goals .....	18
Self-Assessment and Peer Assessment.....	19
Feedback .....	20
Gaps in the Literature.....	21
<b>Chapter III: Research Design and Methods.....</b>	<b>23</b>
Study Context.....	23
Research Design.....	24
Participants.....	24
Class Context .....	29
Timeline .....	29
Description of Strategy Implementation.....	29
Data Collection .....	31

Truth box.....	31
Interviews.....	32
Data Analysis.....	32
Researcher Background.....	36
Limitations.....	36
<b>Chapter IV: Findings.....</b>	<b>38</b>
Models Summary and Organization.....	38
Formative Assessment Strategy Models.....	39
Self-Assessment.....	39
Formative Use of Summative Tests.....	39
Questioning.....	40
Feedback.....	41
Themes Across All Strategies.....	43
Assessment Prep.....	43
Clarify.....	46
Individualized.....	50
Informs the Learner.....	53
Themes Overlapping Strategies.....	57
Know What is Wrong.....	57
Positive Internal Feeling.....	59
Second Chance.....	60
Deeper Understanding.....	62

Themes Unique to Individual Strategies.....	65
Questioning.....	65
Involved in Learning.....	65
Social.....	66
Time for Questions .....	67
Self-assessment.....	68
Break it Down.....	68
Evaluate Self.....	69
Focus.....	70
Sets Goals.....	70
Prevents Use.....	71
Feedback.....	73
Not Used .....	73
<b>Chapter V: Discussion, Implications, and Suggestions for Future Research.....</b>	<b>76</b>
Discussion of Major Findings.....	77
Self-assessment.....	77
The "Anti-Clump" Factor .....	79
Formative Use of Summative Tests.....	79
Questioning.....	80
Feedback.....	81
Conclusion .....	82
De-Mystifying the Learning Experience .....	83

Growth Mindset .....	84
Accessible .....	84
Closing the Gap.....	85
Implications.....	86
Suggestions for Future Research .....	88
<b>References</b> .....	<b>90</b>
<b>Appendix A</b> .....	<b>99</b>
<b>Appendix B</b> .....	<b>101</b>
<b>Appendix C</b> .....	<b>103</b>
<b>Appendix D</b> .....	<b>107</b>
<b>Appendix E</b> .....	<b>110</b>
<b>Appendix F</b> .....	<b>114</b>
<b>Appendix G</b> .....	<b>115</b>

## List of Tables

Table 2.1 <i>Key Strategies of Formative Assessment</i> .....	14
Table 3.1 <i>Descriptions of Student Participants</i> .....	26
Table 3.2 <i>Themes Within and Across Formative Assessment Strategies</i> .....	35

## List of Figures

Figure 4.1 <i>Model of Students' Perceptions of Self-Assessment</i> .....	39
Figure 4.2 <i>Model of Students' Perceptions of Formative Use of Summative Tests</i> .....	40
Figure 4.3 <i>Model of Students' Perceptions of Questioning</i> .....	41
Figure 4.4 <i>Model of Students' Perceptions of Feedback (Whole Class)</i> .....	42
Figure 4.5 <i>Model of Students' Perceptions of Feedback (Individual)</i> .....	43

## **Chapter I: Introduction**

### **Rationale**

Assessment happens daily in the classroom. Assessment occurs formally or informally, is embedded in the lesson plan or done on the fly, and can be formative or summative. A given assessment can reveal students' understanding, determine students' current abilities, supervise students' progress, acquire evidence to gauge students' achievement, and guide the teacher in making decisions about planning instructional activities (NRC, 1996). Formative assessment, specifically, employs a series of strategies designed to improve teaching and learning that use student understanding to guide decisions about instruction during the learning process (Carlson, Humphrey, & Reinhardt, 2003; NRC, 2001a). Ultimately, formative assessment aims to have ongoing assessment of students' learning in order to close the gap between their understanding and the intended learning goals (Sadler, 1989).

In classrooms that incorporate formative assessment, less emphasis is placed on competition between students, rote memorization, and quantity of learning and more emphasis is placed on personal improvement, understanding, and quality of work (Black & Wiliam, 1998b). With this shift in emphasis in the classroom, formative assessment has been shown to improve learning for all, particularly low-achieving students (Black & Wiliam, 1998a). This is of significant importance with the current achievement gap in areas of mathematics and science, especially in urban schools with diverse populations that require teaching methods to combat this systemic underachievement (Lee, 1999). Teaching methods that embed culturally relevant pedagogy and high expectations for

students helps to counter low achievement (Casteel, 1997; Ladson-Billings, 1994; Prime & Miranda, 2006).

Despite national science initiatives (NRC, 1996; NRC, 2001a) that push for the use of formative assessment, most of the current research has focused on teacher involvement in formative assessment and teacher implementation of formative assessment strategies (e.g. Black & Harrison, 2001a; Gioka, 2009; Sato, Coffey, & Moorthy, 2005), rather than the ways students use and participate in formative assessment. While both teachers and students are involved in formative assessment, they do so in different ways. Teachers use formative assessment to gather information about student understanding in order to improve and adapt instruction for student learning (Black & Wiliam, 1998a; Wiliam & Leahy, 2007), whereas, students are expected to integrate the information (or feedback) from formative assessment into their learning while engaging in student-centered formative assessment like self- and peer- assessment (Black & Harrison, 2001b).

### **Statement of the Problem**

While the research shows formative assessment improves achievement for all students (Black & Wiliam, 1998a) and assists students in understanding how to bridge the gap in their learning (Sadler, 1989; Stiggins, Arter, Chappuis, & Chappuis, 2004), it is unclear whether or not students perceive formative assessment to be beneficial, particularly those students in urban science classes. Amid all the educational movements, one has to wonder if students are using formative assessment in the way it is intended or if it represents yet another educational hoop they must jump through. The argument has been made that in order to understand formative assessment in practice, continued

research must focus on the perceptions and perspectives of students involved (Cowie, 2005b). Thus, this study aims to understand how students use and perceive formative assessment within an urban secondary science class.

### **Goals and Objectives**

This study is designed to develop an understanding of urban science students' uses and perceptions of formative assessment. The research questions that guide the study are:

How do students use formative assessment in science class?

What are student perceptions of formative assessment in science class?

How do students use formative assessment in their learning?

### **Potential Significance of the Study**

This research is significant because it investigates how urban learners use formative assessment in science and informs decisions about learning in urban settings. With around 80% of the US population living in urban areas (U.S. Census Bureau, 2012), a closer investigation of urban students and the ways in which they perceive their learning is crucial to closing the achievement gap. Most formative assessment research up to this point has focused on students' self-assessment of learning, student achievement and motivation, and teacher involvement in the implementation of formative assessment strategies (e.g. Andrade, 2010; Furtak & Ruiz-Primo, 2008; Ruiz-Primo & Furtak, 2007; Sato, Coffey, & Moorthy, 2005; Yin et al., 2008). Minimal research has been conducted that focuses on students' perceptions about formative assessment (Brookhart, 2001; Cowie, 2005a; Cowie, 2005b) and no studies focus on the experiences of mainstream secondary science students in urban schools.

Given Cowie's (2001b) argument about the importance of understanding student perceptions of formative assessment, continued research needs to be conducted, especially with the increasing popularity of formative assessment in science education initiatives (NRC, 2001b; NRC, 2012). Certainly, there is more to learn about student perspectives and uses of formative assessment. This dearth of research indicates a need for an expansion on previous studies and a more in-depth look at student perceptions. If formative assessment involves teachers adjusting their instruction based on students' learning, then understanding the how and why certain strategies of formative assessment are effective for students is crucial. By understanding students' views and the ways formative assessment affects their learning and motivation, teachers can implement the formative assessment strategies that are the most successful and in ways that are effective.

### **Definitions**

In this study, *formative assessment* in this study is meant to be any technique implemented to gain or communicate information about a student's knowledge and understanding in order to guide learning and instruction. There are a variety of strategies including, but not limited to feedback, questioning, formative use of summative tests, self-assessment, and peer assessment; these strategies can take on an informal or formal nature. Some of these strategies originate with the teacher (e.g. feedback) while other strategies are student initiated (e.g. self-assessment).

### **Overview of Following Chapters**

Chapter II provides an overview of the literature starting with an explanation of the types and purpose of assessment (formative, summative, and reporting). From there

the focus shifts to the theory of formative assessment and elements of formative assessment. Then there is a review of previous studies, which discuss how teachers practice and implement formative assessment. Finally there is a discussion of the research that looks at the ways students engage in formative assessment.

Chapter III outlines the research design and provides an explanation for the use of qualitative methods, particularly an emergent and inductive approach to researching students' perceptions of formative assessment. There is also a detailed description of the context, timeline, and participants of the study. I discuss the methods of data collection with the truth box vignettes and interviews along with a detailed analysis of the coding process. Chapter III concludes with my background as the researcher and limitations to the study.

In Chapter IV I describe my findings and present the models for each of the specific formative assessment strategies. I provide a description of each of the themes that emerged within each model and how they connect to the students' experiences.

And Chapter V summarizes the major lessons learned from the study and comments on the main themes in light of previous literature. I discuss the lessons learned regarding students' perceptions, and I examine the implications as they relate to teachers' implementation of formative assessment in urban settings and the implications for future research on this topic.

## **Chapter II: Review of the Literature**

Assessment of students is a daily part of classroom practices used to ascertain a student's prior knowledge and misconceptions, monitor a student's progress, and determine a student's understanding of material (NRC, 1996). Assessment serves summative, formative, and evaluative purposes, and while traditionally the word assessment conjures images of the end of unit paper and pencil test, today's assessment involves more regular interactions between teachers and students. Formative assessment specifically aims to improve teaching and learning while using student understanding to guide decisions about the direction of instruction (NRC, 2001a). Teachers monitor students' progress to decide how to proceed in a unit and immediate adjustments are made to help students learn (Shepard, 2008). Emphasis is shifted from content memorization and rote recall to the process of learning (NRC, 1996).

## **Theoretical Framework**

In education, there are three key purposes of assessment: formative, summative, and evaluative. Each of them serves a different, but important function with its own set of outcomes. The next section describes each assessment and its role in the larger scheme of assessment.

### **Formative assessment**

Formative assessment promotes learning and guides teaching (Black & Wiliam, 1998b; Wiliam, 2008) and is a process that assists students in their learning while providing information to teachers to inform their teaching (NRC, 2001b). While the phrase “assessment for learning” has sometimes been used interchangeably with formative assessment, recent clarification has noted that although both ideas promote learning, assessment becomes formative when instruction is changed to meet the needs of the learner (Black, Harrison, Lee, Marshall, & Wiliam, 2004). In formative assessment, teachers use the information they elicit from students to drive their instruction and meet the students’ needs to enhance learning.

Formative assessment happens in what the literature refers to as “real time” (Wiliam, 2008). Formative assessment is meant to be ongoing as learning is happening daily (Carlson, Humphrey, & Reinhardt, 2003). The assessment is happening as instruction is happening—rather than as an afterthought. By embedding the assessment into the curriculum teachers can better meet the needs of students and “keep learning on track” (Wiliam, 2008). Due to the highly interactive nature of formative assessment, students are in communication with teachers, whether through oral questioning or written assignments. Based on students’ understanding teachers can make modifications in their

lessons and via feedback during instruction, teachers assist students in meaningful learning (McMillan, 2007).

### **Summative assessment**

Summative assessment happens at a cumulative place in the learning process, usually the end of a unit, semester or year, and serves to inform about and document a student's learning (McMillan, 2007). These sorts of assessments "intend to capture what a student has learned, or the quality of the learning, and judge performance against some standards" (NRC, 2001a). Any assessment that comes at the end of learning with the purpose of monitoring overall achievement and knowledge or comprehension can be deemed summative (Leahy, Lyon, Thompson, & Wiliam, 2005; McMillan, 2007).

Examples include but are not limited to laboratory reports, final projects, and portfolios. The information from summative assessments, like final exams and standardized tests, involve a student's level of attainment or retention. The purpose of summative assessments is to identify what a student has achieved (NRC, 2001b).

Summative assessment happens after instruction (McMillan, 2007). The results of the assessment, especially large-scale standardized tests, provide information too late for teachers to make any changes for the benefit of the current class of students (Leahy et al., 2005). Although a teacher can make changes later on to benefit a certain unit or entire course, these changes do not have any immediate impact.

As the name suggests, summative assessments summarize the achievements of students (Sadler, 1989):

*Summative* contrasts with formative assessment in that it is concerned with summing up or summarizing the achievement status of a student, and is geared towards reporting at the end of a course of study especially for purposes of certification. It is essentially passive and does not normally have immediate

impact on learning, although it often influences decisions which may have profound educational and personal consequences for the student. (p. 120)

### **Evaluative assessment**

When the information about student achievement from summative assessments directs important decisions, the nature of the assessments becomes high stakes (Harlen, 2005). When these high stakes tests are used to look across programs, then the purpose of the assessment changes to one of evaluation in order to report about educational programs (NRC, 2001b; NRC 2012). Scores from standardized tests are compared across institutions to determine the effectiveness of the instruction and quality of the programs. This form of assessment or reporting provides principals, superintendents, and policy makers with information about performance at the classroom, school, district, state, or national level. In an age of accountability for student achievement, these assessments allow administrators to evaluate the performances of their students against other students.

All three purposes of assessment serve a function in education. Certain assessments can serve multiple purposes, but there is the argument that there are trade-offs when this starts to happen (NRC, 2001b). Of course, formative and summative assessments are more prevalent in the classroom, whereas assessment for evaluation is meant for programs and reporting to ensure accountability. Another way to think of summative assessment is the end result of learning or quality control, while formative assessment diagnoses weaknesses along the way and adjusts instruction to address those weaknesses to provide quality assurance (Leahy et al., 2005). The next section discusses how formative assessment ensures this quality in learning.

## **Theory of Formative Assessment**

This study is grounded in the theoretical framework of formative assessment: the idea is to elicit information from students about their learning so that teachers can use that information to guide instruction in order to move students' learning forward.

**Closing the gap.** In his article about formative assessment and feedback, Sadler (1989) talks about closing the gap between a student's current performance and the desired performance. In order for this to happen, three conditions must be met:

1. students have a concept of the standard or goal being aimed for;
2. students compare the current level of performance with the standard;
3. students engage in action that closes the gap between the current performance and the standard. (Sadler, 1989, p. 121)

Another way to describe these conditions is in the form of guiding questions (NRC, 2001a): "Where are you trying to go?; Where are you now?; and How can you get there?" (p. 26). By addressing these conditions or questions, students and teachers are able to use the information from formative assessment to close the gap between students' current understanding and the targeted learning goals. According to Ramaprasad (1983), formative assessment (or "feedback," as he called it) is only effective if it closes the gap: "Feedback is information about the gap between the actual level and the reference level of a system parameter which is used to alter the gap in some way" (p. 4). This feedback, or formative assessment, essentially moves student learning forward from an initial point of understanding.

**Inside the black box.** In their review of the literature, Black and Wiliam (1998a) found that formative assessment improves learning for all, but particularly helps learning for low-achieving students. These students are able to receive the feedback they need to understand what is wrong and how to improve, without being compared to other students.

Feedback needs to be of high quality, focus on mastery rather than performance, and be given to individual students so they can advance in their specific areas of weakness. This feedback can also be applied formatively to scores on summative assessments to help students know where they need to make improvements. Students can also engage in self and peer assessment to determine any gap in their learning; from there, they work to close the gap with an emphasis on personal improvement and learning.

**Assessment for student learning.** Stiggins and Chappuis (2006) provide the following definition for assessment for learning:

Assessment *for* learning happens in the classroom and involves students in every aspect of their own assessment to build their confidence and maximize their achievement. It rests on the understanding that students, not just adults, are data-driven instructional decision makers. (p. 11)

In their article, Stiggins and Chappuis (2006) challenge the definition used by test publishers that formative assessment is merely administering a test multiple times in a given year. They expand their definition of formative assessment to also include the idea of assessment for learning. In their book, *Classroom Assessment for Student Learning: Doing it Right-Using it Well* (Stiggins, Arter, Chappuis, & Chappuis, 2004) they outline five keys to classroom assessment quality. These include: clear purpose for the assessment, clear learning targets, well designed assessments that reflect the learning targets, effective communication of the assessment results, and student involvement in their own assessment. Most of these practices connect back to providing clear learning targets to students. These learning targets take content standards and put them into student friendly language for students to use. The goal is implementing assessments for learning purposes that clearly communicate between students and teachers.

**Motivation.** Traditionally, the students who were motivated to work hard would learn and those students who were not motivated to work hard would not learn (Stiggins, 1999). Decades of research by Dweck (2000) demonstrates the relationship between students' perception of their intelligence and their motivation. Students who perceive intelligence as fixed or unable to change often exhibit helpless patterns. On the other hand, those students who perceive intelligence as malleable exhibit mastery-oriented patterns. When faced with a challenge, mastery-oriented students take the opportunity to learn and put forth more effort, rather than shut down because a seemingly insurmountable task makes them feel vulnerable and dumb. By encouraging students to be owners of their own learning through formative assessment (Wiliam, 2008), they will be pushed to grow on cognitive and emotional levels.

Formative assessment is a way to intervene in order to increase student learning while encouraging students to become effective learners. In the process of developing deep understanding and reasoning, clear learning goals and effective communication shift the motivation for learning to the student (Stiggins, 1999; Stiggins, 2007). Learning becomes intrinsically motivating. Rather than teachers or grades being the motivator (or a complete lack of motivator), intrinsic factors within the student become the motivator.

### **Review of Literature**

In their literature review Black and Wiliam (1998a) discuss how teachers and students use formative assessment. The following section provides a review of the research regarding how teachers implement formative assessment and the ways students use formative assessment. The last section describes the gaps in the literature regarding students' perceptions of formative assessment.

## **Key Strategies**

In order to implement formative assessment, certain aspects of the classroom need to be in place. Some suggestions to prepare include: setting up a classroom that encourages interaction and different assessment tools, following students' learning goals, using differentiation with students, assessing students in a variety of ways, providing feedback to students, and involving students in the learning process (Centre for Educational Research and Innovation, 2005). Still other studies suggest specific key strategies of formative assessment for teachers to implement and engage their students. In the follow-up study to their seminal article on formative assessment, Black and Wiliam and colleagues (2003, 2004) outline the following critical practices of formative assessment: questioning, feedback with comments and without grades, peer assessment and self-assessment, and formative use of summative tests. In their discussion about integrating assessment with learning, Wiliam and Thompson (2008) outline five key strategies and how they relate to the instructional processes described by Ramaprasad (1983): clarify and share learning intentions and criteria for success; engineer effective classroom discussions, activities, and tasks that elicit evidence of learning (questioning); provide feedback that moves learners forward; activate students as instructional resources for one another (peer assessment); and activate students as owners of their own learning (self-assessment). These and other studies (Black & Wiliam, 1998b) that discuss key strategies of formative assessment are depicted in Table 2.1.

Table 2.1

*Key Strategies of Formative Assessment*

Study	Key Strategies					
<b>Black &amp; William (1998b)</b>	Feedback	Questioning	Self-assessment	Peer-assessment		
<b>Black et al. (2003)</b>	Feedback	Questioning	Self-assessment	Peer-assessment	Formative use of summative tests	
<b>Black et al. (2004)</b>	Feedback	Questioning	Self-assessment	Peer-assessment	Formative use of summative tests	
<b>William &amp; Thompson (2008)</b>	Feedback	Questioning	Self-assessment	Peer-assessment	Clear learning goals/criteria	

**Teachers and Formative Assessment**

Teachers observe everything from a student’s body language to gestures to engagement to responses on an activity to make decisions about student understanding or misunderstanding. With this information teachers review confusing material or target the learning of a few individual students before moving on to new material. Feedback or information from students feeds back into the classroom and the teacher’s decisions about instruction in order to improve the lesson or delivery, and the teacher adapts to the needs of the students (William & Leahy, 2007). Ultimately, through the use of formative assessment, teachers can adjust the culture of their classrooms. Instead of developing a culture of testing, teachers can develop a culture of assessment in order to support

learning. For example, in Treagust, Jacobowitz, Gallagher, and Parker's (2001) study, one teacher used student responses to the different assessment to adjust her instruction and create the next lesson in order to achieve this change in classroom culture.

Conversely, teachers have the expertise and control to grade the assessments and may not feel that assessment is part of students' classroom role (Sadler, 1989). In their study, Black et al. (2004) found teachers expressed concern over losing control in the classroom due to formative assessment. After introducing formative assessment in the classroom and working through different strategies, those same teachers felt something completely different. They noted the sharing of responsibility for learning with their students. Teachers and students developed a working relationship that fostered the needs of the students.

**Providing learning goals.** Providing students with the learning goals (e.g. rubrics) ahead of time allows them to know how they will be evaluated. If rubrics are involved, students can self-assess with the rubric as another way to promote effective learning (McTighe & O'Connor, 2005). Students reflect on where they are at this point in time and think about where they want to be with their learning using the learning targets that provide them with the standards translated into student friendly terms (Stiggins et al., 2004). Specifically, these goals allow students to know where they are going with their learning.

**Questioning.** Questioning with student learning in mind involves more "wait time" after the teacher poses the question (Rowe, 1974). By allowing more time after asking a question, students have more time to think. Their responses become more thoughtful and less quick regurgitation of facts. Teachers also have the opportunity to

assess students' prior knowledge and conceptions or misconceptions about certain topics. The discussion moves away from an exchange of right and wrong answers, to one of problem solving and sharing. Open-ended questions are used to start a lesson and meaningful follow-up afterward is used to extend and explore student understanding (Black et al., 2004). The focus is shifted from students being passive receivers to active learners who express and develop their own understanding.

**Feedback.** Feedback to students is a crucial factor in formative assessment. Hattie and Timperley (2007) define feedback as "...information provided by an agent (e.g., teacher, peer, book, parent, experience) regarding aspects of one's performance or understanding. It occurs typically after instruction that seeks to provide knowledge and skills or to develop particular attitudes" (p. 102). Nicol and Macfarlene-Dick (2006) take the idea of feedback one step further to incorporate more student involvement. In their seven principles of feedback, students take on a proactive role, rather than a reactive one, in the use and production of feedback. They combine ideas from Sadler and other researchers to note that good feedback needs to: "clarify what good performance is, facilitate self-assessment, deliver high quality feedback information, encourage teacher and peer dialogue, encourage positive motivation and self-esteem, provide opportunities to close the gap, and use feedback to improve teaching" (Nicol & Macfarlene-Dick, 2006, p. 203). These principles encompass strategies beyond just feedback in order for students to take on a proactive role.

According to Wiliam (2008) the kind of feedback makes a difference in how to move learning forward. When quality feedback is given (i.e. constructive and positive comments) students know how to improve (Black et al., 2004). Students only show an

increased interest in their learning when they receive specific grade-free comments; they show less interest with comments that include grades because they focus on the grades (Butler, 1988). Feedback is most effective when it focuses on processing information or self-regulating (Hattie & Timperley, 2007). The feedback provides individualized information to students about their progress, which they can compare to the learning goals they are supposed to meet. Cowie's findings (2005a, 2005b) revealed that students welcomed feedback in the form of suggestions in semi-private interactions when they wanted to develop understanding; students wanted less questioning and more help if they were working on a task; and trust and respect were important if students were going to disclose information to teachers upon questioning.

**Formative use of summative assessments.** Black et al. (2004) discuss the practice of using summative assessments formatively. The results from the test inform the teacher about where she needs to go back and re-teach a concept. After the assessment, time is set aside to go over missed concepts in order for students to reflectively evaluate their work. Students compare their current understanding of the topics from the tests against the set learning targets. Guskey (2008, 2010) argues these types of corrective activities paired with feedback leads to significant improvement in student understanding. The corrective activities are specific to each student's learning needs and are most effective when they present the material in a new way, engage students in a new way, and provide successful learning experiences that lead to confidence and motivation (Guskey, 1997).

**Formative assessment continuum.** Formative assessment practices exist on a continuum from formal to informal. Shavelson et al. (2008) describe three types of

formative assessment on the continuum—informal unplanned, planned and formal. “On-the-fly” formative assessment is informal and unplanned, often happening as a teacher is walking around the room listening and engaging in discussions with students. This represents the “teachable moment” when a teacher can offer ideas or questions to challenge or guide students’ comments. The second method of formative assessment is planned-for-interaction. This approach involves a plan or assessment prompt the teacher prepares in advance. For a discussion a teacher might write a series of questions to get at key concepts. The third technique is called embedded-in-the-curriculum. Just as the name states, the formative assessment is embedded into the unit after important concepts are taught in order to see what students know and still need to learn before moving on. This technique is formal and often designed by curriculum developers or in conjunction with teachers for their use in the classroom (Wiliam, Lee, Harrison, & Black, 2004).

### **Students and Formative Assessment**

In order for students to be successful and move their learning forward, they need to have clear learning goals, quality examples to compare their work against, constructive descriptive (not evaluative) feedback, and time to reflect and respond to feedback (Black et al., 2003; Sadler, 1989). All of these formative assessment practices contribute to assessment for learning and allow students to become active and motivated in the learning process.

**Understanding learning goals.** Giving students criteria (e.g. rubrics, learning criteria, learning targets) ahead of time allows them to know how they will be evaluated. As students try to answer the question of “Where am I trying to go?,” clear standards and goals provides students with a learning target. Teachers design learning targets to reflect

the content standards into classroom-level, in student friendly language (Stiggins et al., 2004; Stiggins & Chappuis, 2006). Students are able to use these clear criteria, often in the form of rubrics, to set their learning path. They use self-assessment to figure out where they need to go on that learning path.

**Self-assessment and peer assessment.** Student self-assessment and reflection on their own understanding is clearly stated as part of the recommended assessment practices in the National Science Education Standards (NRC, 1996). In order for students to become involved in the learning process and be able to answer the question “Where am I now?,” there has to be some focus on self-assessment. When students identify what they have learned and the purpose of the learning, they understand what they need to do to achieve (Black & Wiliam, 1998b). Reflecting throughout the lesson helps students understand their own learning. In order for self-assessment to be effective, students need to practice evaluating work and identifying quality work. Students need clear learning targets with which to evaluate their work and practice using criteria. In order for students to be able to engage in self-assessment, teachers need to understand that “direct and authentic evaluative experience is a necessary (instrumental) condition for the development of evaluative expertise and therefore for intelligent self-monitoring” (Sadler, 1989 p. 143). The same approach to develop self-assessment in learners also applies to teach students how to engage in peer assessment, the act of assessing another’s work.

With practice, students develop skills to self-assess and peer-assess. In this way students become agents of their own learning and take ownership within the aspects of formative assessment (Wiliam & Black, 1998a). In her interviews with successful

English and anatomy students, Brookhart (2001) observed that these students engaged regularly in self-assessment. They used assessments in a variety of ways and did not make divisions between summative and formative. Successful students know how to interpret feedback view assessment as a process, regardless of the nature of the assessment. Students felt comfortable with self-assessment, provided they had sufficient practice and were aware of the teacher's expectations, and felt it benefited their motivation, learning, quality of work, and grades (Andrade & Du, 2007). While in Hanrahan and Isaac's (2001) study about student views of self and peer assessment, students reported difficulties when they were unsure of the standards and could not be objective about marking themselves, they did note that benefits included a better understanding of the grading, improvement of their own assignments, and development of critical thinking skills.

**Feedback.** Students use the information from feedback to take an active role in their learning. Feedback can come from either teachers or other students, but ideally needs to contain quality comments that are enforcing what the student is doing well and how the student can improve (Black et al., 2004). If students receive grades with the comments, then they focus their attention on the grades and ignore the comments. Only when the comments are alone have they shown to increase students' interest in learning. The giving of grades as a form of feedback actually decreases motivation and has a negative effect on low-achievers (Butler, 1988).

Formative assessment appears to establish a community of learners where the relationship between teachers and students becomes one of shared responsibility for learning (Brookhart, 2003). The classroom culture takes on a different feel and changes

the traditional dynamics. When students are given the opportunity to respond and reflect to teacher and peer feedback, then the learning and improvement is in their hands (Black et al., 2004). When students are given sets clear learning targets, then they know where they have to go with their learning (Stiggins et al., 2004). Small academic successes are encouraged to counteract the consistent failures many students have had in the classroom. In this way they build up their confidence and intrinsic motivation (Stiggins, 2009).

### **Gaps in the Literature**

National initiatives (NRC, 1996; NRC, 2001a; NRC, 2012) recognize student self-assessment and reflection as part of assessment practices. This push for student involvement in formative assessment validates the need for an understanding of their perceptions and experiences. As Brookhart (2003) notes:

Whether the teacher uses student- centered methods or not, the student occupies a central role in this formative process because only he or she can take the actions necessary to improve. The teacher cannot learn “for” the student. The formative assessment process itself is a part of the learning because it is in this process that students come to understand the standard of quality work with which their work is compared. (p. 7)

Although there is research about students’ self-regulation and self-assessment to be their own “producers and consumers of formative assessment” (Andrade, 2010), little research has been done beyond a few studies about student perceptions and views of formative assessment (Brookhart, 2001; Cowie, 2005a; Cowie, 2005b). Cowie (2005b) argues that “attention to pupil perspectives and experiences of formative assessment are therefore crucial to any understanding of how assessment for learning is and might be accomplished in practice” (p. 140).

Given this argument about the importance of understanding student perceptions, one has to question why the topic has been under-researched in the last few years.

Certainly, there is more to learn about student perspectives and uses of formative assessment, especially in the light of the recent research done with respect to practices, student involvement, and teacher involvement (e.g. Furtak & Ruiz-Primo, 2008; Gioka, 2009; Ruiz-Primo & Furtak, 2007; Sato, Coffey, & Moorthy, 2005; Wenzel, 2007; Yin et al., 2008). This dearth of research indicates a need in the literature for an expansion on previous studies and a more in-depth look at student perceptions. If teachers are to adjust their teaching for students, then understanding the most effective methods of learning from the student's point of view is important. When adjustments are made according to the teacher's view, rather than in collaboration with students' views, then only one component of the classroom is addressed, rather than the whole classroom. Research that only focuses on teacher experiences discounts the other half of the classroom: the student. By understanding student views and how formative assessment improves their learning and how it motivates them, then teachers can use the strategies in ways that are most effective and successful.

## **Chapter III: Research Design and Methods**

### **Study Context**

This study was situated in a medium-sized urban high school in the first ring suburbs of Minneapolis. Formative assessment had been a popular topic in the district, and the science and math departments at the high school, including my own chemistry classes at the high school, had been actively implementing different aspects of formative assessment. For the three years leading up to my study I had been slowly integrating self-assessment using clear criteria or learning targets into all of my chemistry units. By the time I started collecting data I had developed learning targets for each of the 10 units taught in introductory chemistry. Even though the learning targets were established, I had each class at the beginning of the year develop their own self-assessment scale using student friendly language. Students described their feelings and skills associated with each level of understanding on the one through five scale, with five being the highest level of understanding and one being the lowest level of understanding. A detailed description of the scale developed by the students can be found in Appendix A with the learning targets used for the periodic table unit.

In the year prior to collecting data I had implemented the strategy of using summative tests formatively and had spent time writing the retakes that went with each of the assessments. I was also used to providing descriptive, written feedback on multi-draft assignments (e.g. laboratory reports, research papers). For my dissertation I decided to expand upon the existing district initiatives and the strategies I had already been implementing as well as include one new strategy—questioning. My intent was to bring some of the more informal, implicit formative assessment approaches to the forefront.

While I implemented four major formative assessment strategies (self-assessment, feedback, formative use of summative tests, and questioning) in all of my classes during the fall of 2009, only two of my chemistry classes actually participated in the study. I wanted to focus on chemistry because it was a required course and these classes included mainstream students, as opposed to honors or special needs students.

### **Research Design**

This study involved qualitative methods. An emergent, inductive approach was used to investigate the ways students use and perceive formative assessment in their learning of chemistry. An inductive design means that it “begins with specific observations and builds toward general patterns” and “involves discovering patterns, themes, and categories in one’s data” (Patton, 2002, p. 56 and p. 453). Due to the uncertain and unpredictable nature of the classroom and the student participants, an emergent style that allowed for adapting to situations and students’ needs was necessary (Patton, 2002), rather than take a deductive approach that imposed a priori criteria onto the data (Miles & Huberman, 1994; Patton, 2002). Patterns were allowed to emerge from the data during the sense-making effort (Patton, 2002).

### **Participants**

The student participants included in the study were taking introductory chemistry, which is designed for 10<sup>th</sup> graders and required for graduation. The high school these students attended is medium sized, and set in a first ring, post-WWII suburb of Minneapolis; this high school has an increasingly diverse population. About half of the students at the school received free or reduced lunch and 40% of the students came from a variety of backgrounds: African-American, Latino-American, Caucasian-African

American, Asian American, and Indian American (Minnesota Department of Education, 2011).

The student participants were selected based on parent/guardian consent and student assent, and then self-selected for participation in videotaped sessions. Although two classes of about 30 students each participated in the activities and provided consent for using any written work, only about 20 students provided consent to be videotaped. Of those students, only 14 students volunteered to sit in the “truth box” which resulted in over 40 vignettes. Six female students, five of them white, and one of them African American and eight male students, two of them white, and six of them students of color, were captured in the “truth box.” Of the 14 students who participated in the “truth box,” only eight completed end of trimester interviews. The following students did not complete end of trimester interviews: Ebony, Sarah, Amaya, Kamal, Elonzo, and Max, but their “truth box” vignettes were included in the data analysis. Most of the students were average students with grade points reflecting A’s, B’s, and C’s. Three of the male students were particularly strong students, receiving more A’s than any other grade. Only a few of the students lived outside of the community and some students transferred from other areas. See Table 3.1 for a brief description about each of the students who participated in the “truth box” and the interviews.

Table 3.1

*Descriptions of Student Participants*

<b>Student</b>	<b>Description</b>
Amaya (white female)	Amaya was kind and compassionate. She worked well with all of her classmates and rotated lab groups often. She was always polite and was constantly curious. She was outspoken in a quiet, yet confident way.
Anastasia (white female)	Anastasia had lots of energy. She struggled sometimes to stay focused, but engaged in the hands-on projects. She was funny and worked well with JuanMa.
Brian (white male)	Brian transferred from another school, but his family had roots in the area. He quickly grasped the concepts, and preferred listening to writing as his mode of learning. He was easy going and funny.
Brooke (white female)	Brooke had a gregarious, outgoing personality. She was always smiling and bringing forth her boisterous self. She had an assertive nature that made it seem as if she disregarded other students' opinions.
Ebony (African American female)	Ebony transferred in from another school, then transferred again mid-year. She was happy and easily excited about new activities. She quickly engaged in projects and asked for help when she needed it.
Elonzo (male student of color)	Elonzo enjoyed talking and was very social. He was goofy, oftentimes distracting himself and others with his shenanigans. He had a big smile with limited focus.

Emily (white female)	Emily worked hard and expressed her desire to help people after high school. She was sensitive, but put up a tough front as a defense. She expressed frustration outwardly, but usually worked through it.
Jared (white male)	Jared was very mature and played in the band. He quickly understood most concepts. He was always respectful and preferred working with students who were also more mature.
JuanMa (male student of color)	JuanMa was extremely artistic. He was very kind and thoughtful and worked well with many other students. He was friends with Anastasia.
Kamal (male student of color)	Kamal was quiet and engaged with students with whom he comfortable with in class. He completed his work on time and rarely asked for help.
Max (male student of color)	Max was outgoing and talkative. He easily engaged in class discussions and oftentimes talked to the instructor about a variety of topics.
Raj (male student of color)	Raj was socially mature and even if he was distracted, he completed his work. He preferred working alone or with a partner. He was polite and asked questions when he felt they were appropriate.
Sarah (white female)	Sarah had a positive attitude and worked hard. She got along with all sorts of students and rotated in her lab groups. Due to her occasional feelings of uncertainty, she preferred sharing her truth box experience with either JunaMa or Brooke.

Seba (male student of color)	Seba worked hard at everything he did. He constantly pushed himself and asked questions for clarification. Independent work was easy for him as he maintained a strong focus on assigned projects. He had a calm determination and worked well with all students.
------------------------------------	---

## **Class Context**

**Timeline.** Data collection took place starting the second week of September through the second week of December during the first trimester in the fall of 2009. The trimester ended in the beginning of December, but some of the exit interviews were conducted in the first few weeks of the second trimester due to final exams and scheduling issues since the interviews were conducted outside of class time, either before or after school.

I chose to collect data only during the first trimester for two reasons. The first was that students would have consistency with the teacher as many switch to different teachers at the trimester. Secondly, one trimester provided a enough data to be analyzed for the given scope of the dissertation. The first trimester also had the fewest and shortest holidays so students were never out of the classroom longer than five consecutive days. This allowed for more regular interaction with students.

First trimester included the topics that form the foundation for the rest of the year. The five units in the first trimester included: a unit introducing safety, lab procedures, and measurement; a unit discussing the history of science, laws, theories, and hypothesizes; a unit looking at classifying matter, chemical and physical properties and changes; a unit on the elements and patterns of the periodic table and Mendeleev's struggle; and a unit on the structure of the atom that included nuclear chemistry. Each of the units was written as a collaborative effort with another chemistry teacher.

**Description of strategy implementation.** Activities related to each of the strategies were implemented over the course of the trimester in each of the three units. Students were introduced to the learning targets at the beginning of the trimester and as a

class, they developed a scale for self-assessment in student friendly language. An example of the scale and the qualitative descriptors with the learning targets for the periodic table unit can be seen in Appendix A. Throughout the units, students referred to the learning target handouts to self-assess.

Each unit had an activity or lab that encouraged questioning. During an activity I went from group to group or student to student, asking questions from a list that I had written beforehand. If students exhibited little to no understanding, I would ask them these same questions at a later point in time. Students were also given post lab questions that I used to guide discussions after a lab. See Appendix B for an example of post lab questions.

Students used short quizzes during the unit and long quizzes at the end of the unit as formative assessment. The long quizzes at the end of the unit looked more like summative tests. For shorter quizzes, students had the opportunity to re-assess when the topic surfaced later on a longer quiz. For longer quizzes, students had time in class to complete corrections and then scheduled a time to retake the quiz. Each retake asked different questions, but covered the same material. See Appendix C for an example of a test, Appendix D for an example of a corrections handout, and Appendix E for an example of a retake.

Students received written and oral feedback, both individually and as a whole class. Written feedback was provided on long quizzes, especially when there were short answer and essay questions. Students also received oral and written feedback on their lab reports, getting input as they progressed through the stages of design, test, and reflect. Individual oral feedback involved one-on-one interaction with me. Whole class feedback

followed a quiz or test and included an oral review of material that the majority of students struggled with and usually there was time for oral one-on-one feedback afterward.

### **Data Collection**

Data collection occurred throughout and at the end of the trimester. While the data collection included “truth box” interviews during each unit, exit interviews at the end of the term, and artifacts of student work, the data analysis focused on the interviews of the students as these provided rich accounts of students’ experiences.

**Truth box.** The “truth box” was developed to elicit feedback from the students about their learning as it related to formative assessment, instead of full classroom observations. The concept came out of the need to get targeted responses from students. The information and feedback from students happened in real time. Rather than a long, intense interview, each vignette in the “truth box” was about two minutes and captured a snapshot of their learning. Because I played dual roles of teacher and researcher, the “truth box” allowed me to gather data specific to the study in the moment without too much distraction for the entire class or lesson. The “truth box” set-up was either outside in the hall when class was in session or inside the classroom when class was not in session. Over time the “truth box” developed into a type of confessional where students answered questions about what they learned in each chemistry unit and the use of a particular formative assessment practices. They responded to a series of three questions. See Appendix F for a list and flow of the questions. The “truth box” afforded students a place to express themselves and develop a voice because they knew they were going to be heard.

Within a few days of implementing a strategy of formative assessment (questioning, feedback, self-assessment, and formative use of summative tests), students entered the “truth box.” Over time the “truth box” became a weekly occurrence. Each of the four strategies of formative assessment was addressed in the “truth box” sessions.

**Interviews.** At the end of the trimester I conducted interviews with eight of the 14 students who commented in the “truth box.” Attrition was due to students moving to other schools (two students) or lack of interest in completing a full interview (two students) or lack of time to schedule an interview (two students).

In the interview students responded to questions about the different strategies of formative assessment along with specific features of each. The interviews were semi-structured in nature. See Appendix G for the interview protocol. The protocol provided a general structure to the interview. During the interview students’ responses were probed for more detail or clarification, which may not be reflected in the protocol. At the end of the interview students were also asked if they had any further comments regarding chemistry and their experiences in the class. The interviews lasted from about eight to 20 minutes, depending on the student. All of the students were asked the same questions from the protocol and the differences in length were due to how much students elaborated on their responses to the probing questions.

### **Data Analysis**

NVivo 9.0, qualitative data analysis software, was used to analyze the truth box vignettes and the interviews. Over 40 “truth box” vignettes from the 14 students as well as the eight interviews were transcribed and uploaded into NVivo. The data analysis for this study involved an emergent, inductive approach. The data was not pre-coded—

rather after data collection, the texts were reviewed line by line and categories or codes were assigned (Strauss & Corbin, 1990). Ideas were not imposed a priori or deductively with pre-existing codes or criteria (Miles & Huberman, 1994; Patton, 2002).

During what is known as the open coding process different codes were assigned to the data as categories, patterns, and themes emerged (Rubin & Rubin, 2005; Strauss & Corbin, 1990). The open coding used the four strategies of formative assessment (self-assessment, questioning, feedback, formative use of summative tests) to assist in the organization of the data. These strategies were implemented throughout the trimester and guided the questions students were asked in the “truth box” and interview protocols. Although the “truth box” vignettes were initially organized by unit (laws/theories/hypotheses, periodic table, atom) with the strategies used within each unit, the unit labels were removed because the interviews did not ask questions in the context of specific units, but rather over the course of the trimester. The formative assessment strategies were used to organize the coding of students’ comments. The coded responses were grouped according to the formative assessment strategy they pertained to in the interview. For example, students’ responses that were related to self-assessment were grouped together and coded. This process of grouping and coding data as it related to a specific strategy continued for feedback, questioning, and formative use of summative tests.

After the initial open coding, the codes were revisited and refined. Any codes with only one or two references were combined into a larger more general explanatory theme. Moving on from there, any codes with three or four references were either combined or placed under larger themes as sub-themes. Only in cases where the code

appeared across all four headings was it not combined. Codes that were redundant or similar in meaning were combined under a descriptor that best captured the underlying idea in the codes. Merging continued until each strategy had eight to 11 coded themes. At this point all of the themes within a strategy either overlapped with a theme in another strategy or if the theme was unique to the strategy it had at least six references.

Then, by looking for similarities and differences in the themes across the formative assessment strategies, the themes within the four strategies were compared. Table 3.2 provides a summary of the themes within and across the four strategies. Four themes emerged across all of the strategies, “assessment prep,” “clarify,” “individualized,” and “informs the learner.” Four themes overlapped in two or more areas. For example, “know what is wrong” emerged in formative use of summative tests, and both types of feedback. The other three overlapping themes include: “positive internal feeling,” “deepening understanding,” and “second chance.” And there were eight themes unique to specific strategies. For example, “not used” only appeared under whole group feedback. Unique themes to self-assessment include: “prevents use,” “sets goals,” “evaluate self,” “focus,” and “break it down.” Unique themes to questioning include: “social,” “time for questions,” and “involved in learning.”

Table 3.2

*Themes Within and Across Formative Assessment Strategies*

	<b>Self-Assessment</b>	<b>Formative Use of Summative Tests</b>	<b>Questioning</b>	<b>Feedback Whole Class</b>	<b>Feedback Individual Student</b>
<b>Across all strategies</b>	Assessment prep	Assessment prep	Assessment prep	Assessment prep	Assessment prep
	Clarify	Clarify	Clarify	Clarify	Clarify
	Individualized	Individualized	Individualized	Individualized	Individualized
	Informs the learner	Informs the learner	Informs the learner	Informs the learner	Informs the learner
<b>Overlapping</b>		Know what is wrong		Know what is wrong	Know what is wrong
	Positive internal feeling	Positive internal feeling	Positive internal feeling		
			Deeper understanding	Deeper understanding	
		Second chance	Second chance	Second chance	
<b>Unique to strategy</b>	Prevents use		Social	Not used	
	Sets goals		Time for questions		
	Evaluate self		Involved in learning		
	Focus Break it down				

## **Researcher Background**

For this study, I acted as both researcher and teacher. In class I chose and implemented the formative assessment strategies I wanted to introduce to my students. At the same time I was collecting data about their experiences through the “truth box” and interviews. Throughout the trimester I was the sole interviewer using protocols that I had developed, sometimes in conjunction with members of my committee.

Before embarking on my dissertation, I had already been using some aspects of formative assessment in my classroom, both formally and informally. In fact, it was this prior interest that pushed me to conduct research related to formative assessment for my doctoral program. Previously, I had integrated self-assessment and feedback, but had not used questioning or summative tests formatively. While I was comfortable with some of the strategies, much of the implementation was also a learning process for me as I designed lessons to include all of the strategies. I was constantly adapting to meet the needs of the study while also addressing the needs of my students.

From the beginning I was transparent with my students about the purpose of the study and my interest in understanding their perceptions. Balancing the role of researcher and teacher was a challenge, but I feel that being both allowed me to develop a deeper connection with the students than had I only been an external researcher. This dual role also brought limitations that I discuss in the next section.

## **Limitations**

There are a few limitations to the study. The first limitation is that I was both the researcher and teacher of the students involved in the study. Since I was conducting the interviews, students still saw me as their teacher, even though at that moment I was

taking on the role of researcher. Therefore, I have to recognize a teacher effect. Certainly their responses to some degree were influenced by my dual role; without realizing it they may have responded more favorably to questions because I was their teacher and authority figure in their lives. This is a limitation of being both the teacher and the researcher.

A second limitation is that the study only involved one teacher in one school. Out of the 60 students in the two classes studied; only 14 students consented to be interviewed. While I encouraged other students to participate, due to ethical reasons I could not do more than encourage, and I had to focus the study on those willing to participate. Therefore the results have limited generalizability across other teachers and schools, even though the study does take place with mainstream students in a medium-sized urban high school.

## **Chapter IV: Findings**

This chapter presents in detail each of the themes that emerged from the analysis in Chapter III. Models for each strategy of formative assessment are presented, followed by a brief description of the themes in the model. After the presentation of the models the themes are described, beginning with the themes that were common across strategies and ending with unique strategies. Throughout the descriptions of the themes student comments from the interviews and “truth box” vignettes are embedded.

### **Models Summary and Organization**

After analysis, models were constructed to show the themes that emerged for each of the different formative assessment strategies—self-assessment, formative use of summative tests, questioning, and feedback. Those themes that cut across all four strategies are represented in the models by circular shapes. Semi-circles represent themes that overlapped with two or more strategies. And themes unique to a particular strategy are represented by hexagons in the model. After the models I describe each of the themes in detail. The first sub-section discusses the themes across all strategies: “assessment prep,” “individualized,” “informs the learner,” and “clarify.” The second sub-section describes the themes that overlap strategies: “positive internal feeling,” “deeper understanding,” “know what is wrong,” and “second chance.” And the last sub-section describes themes unique to a particular strategy: “break it down,” “evaluate self,” “focus,” “sets goals,” and “prevents use” for self-assessment; “social,” “time for questions,” and “involved in learning” for questioning; and “not used” for whole class feedback. A brief summary of the theme with comments from students is in each section.

## Formative Assessment Strategy Models

**Self-assessment.** The themes for self-assessment merged into: “assessment prep,” “clarify,” “individualized,” “informs the learner,” “break it down,” “evaluate self,” “focus,” “sets goals,” “positive internal feeling,” and “prevents use.” See Figure 4.1 for a model of all the themes for self-assessment.



Figure 4.1 *Model of Students’ Perceptions of Self-Assessment*

**Formative use of summative tests.** Themes for formative use of summative tests included: “assessment prep,” “clarify,” “individualized,” “informs the learner,” “know what is wrong,” “positive internal feeling,” and “second chance.” See Figure 4.2 that depicts all the themes for formative use of summative tests.

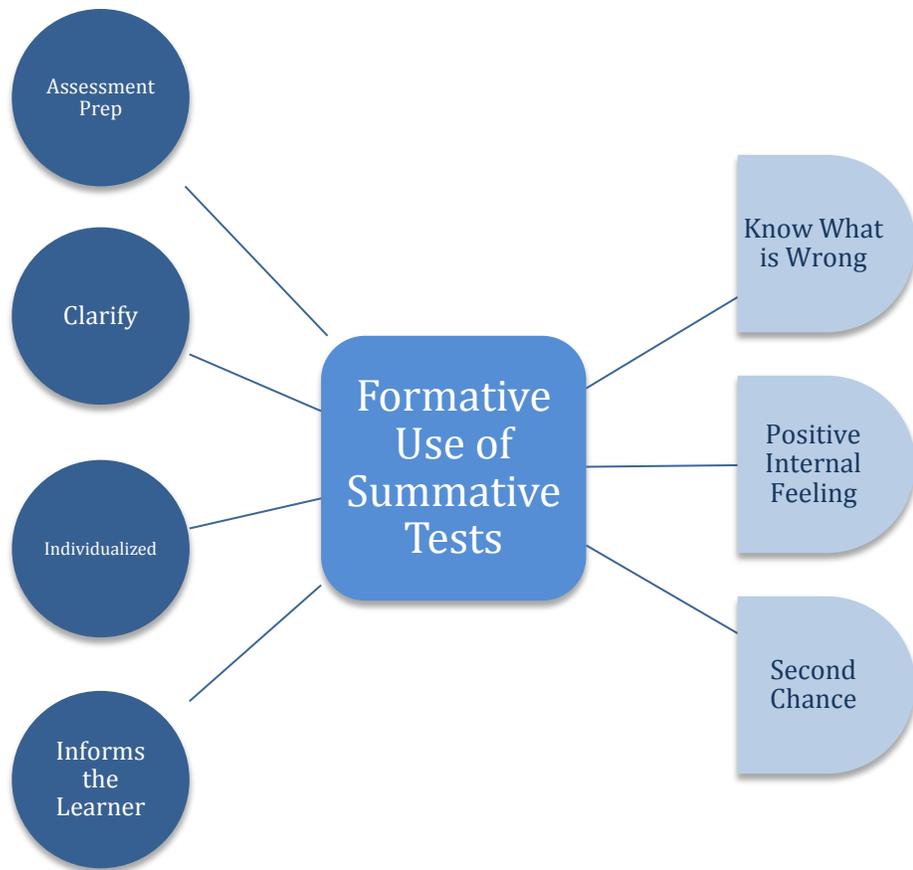


Figure 4.2 *Model of Students' Perceptions of Formative Use of Summative Tests*

**Questioning.** The themes for questioning included: “assessment prep,” “clarify,” “individualized,” “informs the learner,” “involved in learning,” “deeper understanding,” “positive internal feeling,” “second chance,” “social,” and “time for questions.” See Figure 4.3 for a representation of all the themes for questioning.

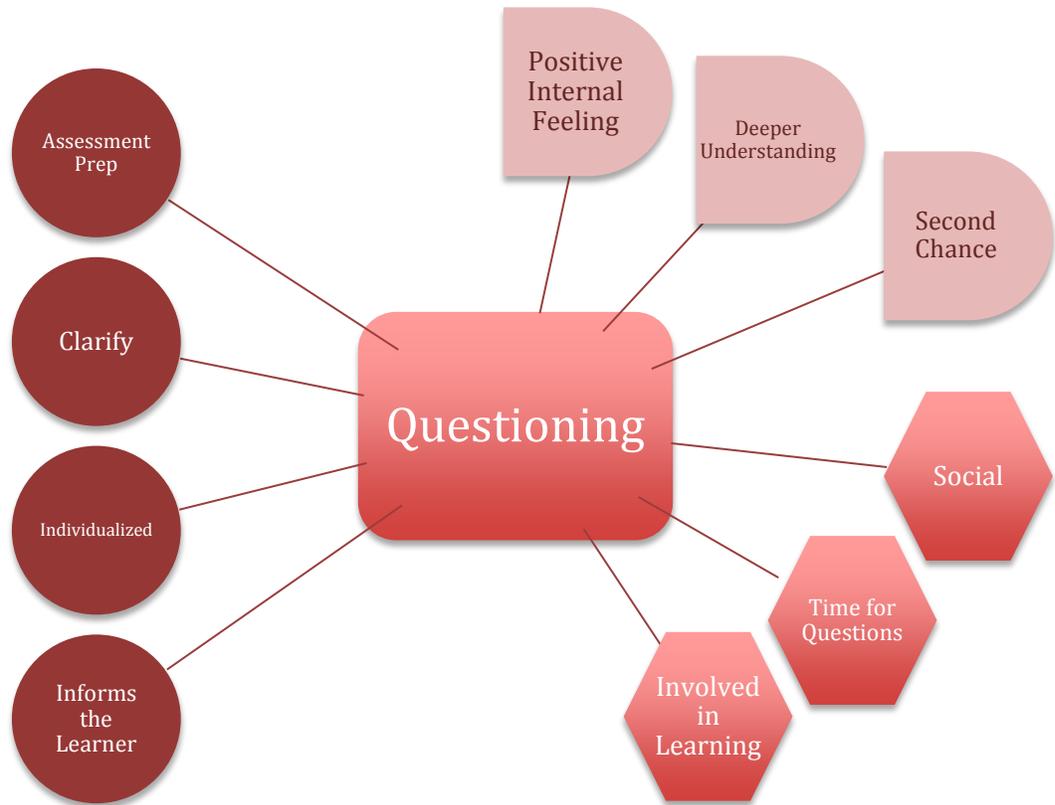


Figure 4.3 *Model of Students' Perceptions of Questioning*

**Feedback.** Feedback separated into two different types, individual student and whole class. For whole class feedback, the themes merged into: “assessment prep,” “clarify,” “individualized,” “informs the learner,” “deeper understanding,” “know what is wrong,” “second chance,” and “not used.” See Figure 4.4 for a display of the themes for whole group feedback.

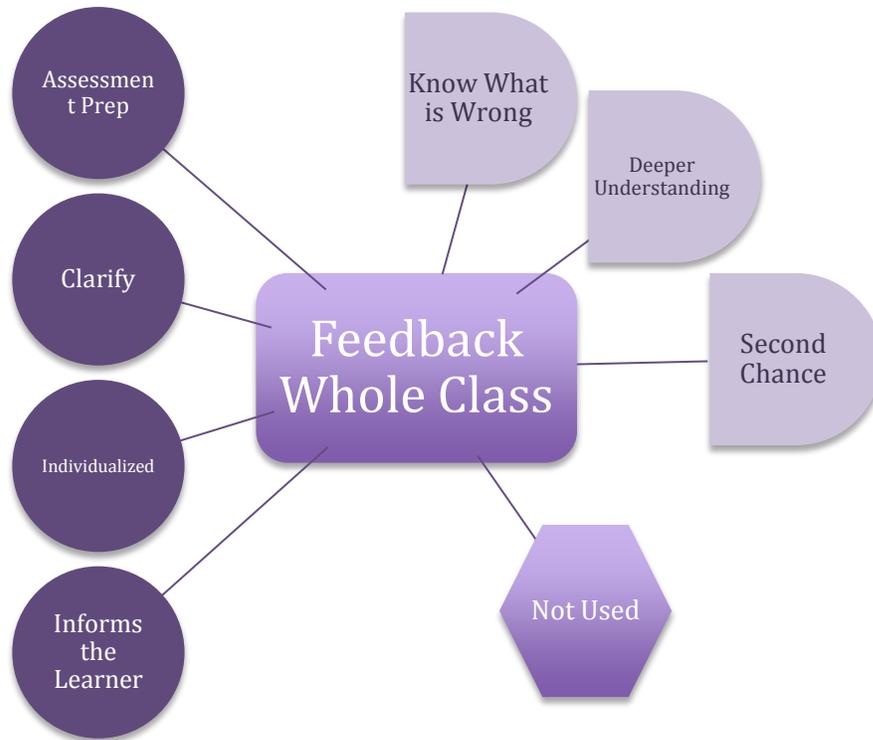


Figure 4.4 *Model of Students' Perceptions of Feedback (Whole Class)*

For individual student feedback, the themes were comprised of: “assessment prep,” “clarify,” “individualized,” “informs the learner,” and “know what is wrong.” See Figure 4.5 for the themes in individual feedback.

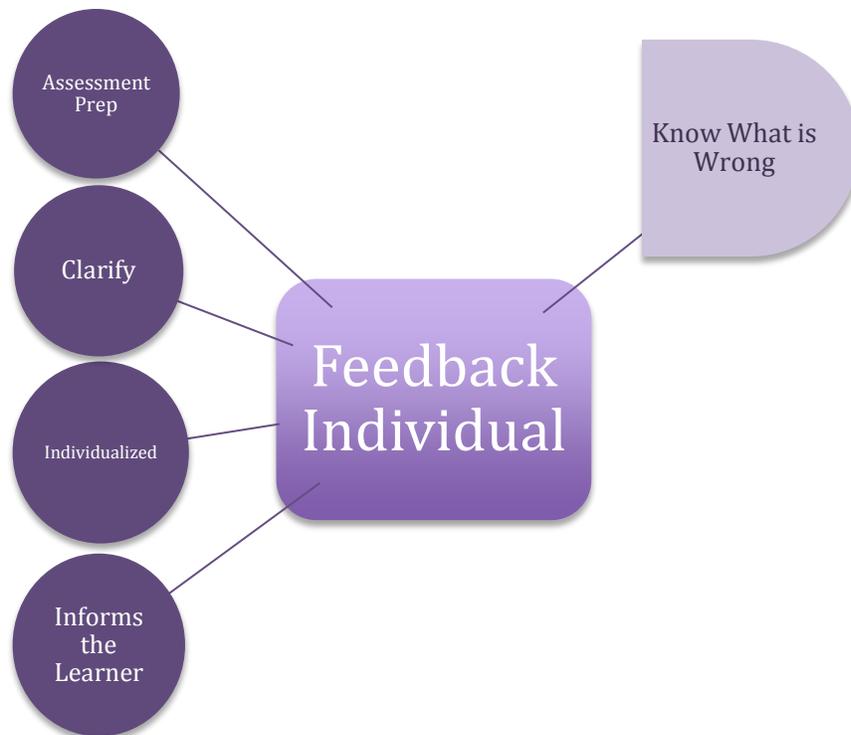


Figure 4.5 *Model of Students' Perceptions of Feedback (Individual)*

### **Themes Across All Strategies**

The following four themes emerged across all four strategies of formative assessment: “assessment prep,” “clarify,” “individualized,” and “informs the learner.” They are represented by circles in the models. In the following sections, each theme is discussed in detail, including the way it relates to each strategy.

**Assessment prep.** “Assessment prep” described all the ways students used formative assessment to prepare for tests and quizzes by studying and reviewing. Students thought studying meant going over material they had not mastered. While students thought reviewing involved going over material they had already learned in order to reinforce concepts. In their minds, formative assessment provided studying and

reviewing opportunities for any kind of upcoming assessment. For Emily, it was the written feedback that guided her studying:

I like feedback because it just helps me to know what I have to study for, and then sometimes when teachers don't put feedback it's really hard to know what I have to study and what I don't have to study. And I just like feedback, it's kind of cool.

Amaya and Jared talked about the ways the whole class feedback functioned to review and reinforce concepts to make sure the material was fresh, especially before a retake:

Amaya: I think that helps to, um, also like I said, again, it helps with the reinforcing it really helps you like go through the information again and it helps it kind of stick in your mind so it's not like you learn it, you go home, you come back to school and you forget everything you learned. Because I noticed with classes that happens to me a lot if we're not reviewing and if we're not studying in a daily basis and you kind of just forget. But this helps that we review it and talk about it in the class and write it down a couple times. I think it helps a lot.

Jared: I think the review is really nice for after, for before the retakes, the reassessments I guess, and before the test itself because it helps refresh the mind for those who don't study. And it helps keep it in your head, keeps you focused on it.

Students also used the test or quiz corrections to help them study. JuanMa was able to study his answers to prepare:

And I also wrote down the right answers and I did study from those right answers. And I did better on this than I thought I would just because I got to study and review.

And Anastasia acknowledged that it took her longer to understand the material and by reexamining her tests, she was able to learn more:

I like it because um, it's helpful for the fact that um... sometimes I don't get it the first time and if I go over it with the class again, or by myself the second time it helps because it's clicking better. And especially if I don't understand it or I forgot what we learned at the beginning of the week and we have the test at the end of the week or the week after, I can know that I can reexamine it and I get it better.

Amaya agreed that by studying the corrections from the first assessment and asking

questions before the retake, she was able to do better:

Because, I mean you get to, like I said before you study more and in case you've forgotten something you can always study before the next retake and that might help you more. And if you're still having problems with it, you can always just ask questions and maybe you're just not getting it. And if you take the retake and you correct it again it can help us understand it better.

Questioning, especially after lab activities, helped students review and prepared for upcoming assessments. As JuanMa and Brian stated:

JuanMa: I think they're helpful because um, whenever we do a lab it's pretty sure that's going to be on the test. And then like the questions, it's basically review before we do the quiz or the test.

Brian: Because they help you review what you have to do for the quiz that you give us like the next day about the lab.

Elzono talked about how the questioning about the lab acted as practice for the test:

Well it just like reviewed, like reviewed like if you're like studying for something, ask these questions and stuff. That's like practicing for the test for like the main thing and stuff like that. So...that's how it helped me.

Self-assessment when it involved using the learning targets helped students organize the way they went about preparing for a test. JuanMa reported:

Um, learning targets... basically you tell us what... like what we're going to be studying about, and before we take the test you say these... we have to know these learning targets to pass the test... the quiz. ... And it's easier like to know what you have to know and what you have to prepare and study for the test.

For Max, the learning targets told him what was going to be on the test so he knew what to study:

Um... Tell us where we need to study. What's going to be on the test and what we need to study. And yeah.

When preparing for a test, the learning targets were something for the students to reference. As Amaya pointed out:

They help me when I have to review for quizzes or tests because if I'm struggling

in certain areas I can just go back and again, look at them to help me remember a certain amount of things about it that I need.

And Brian commented that using the learning targets helped him pay attention to what he needed to study to do well:

It helps you learn like what you need to study more and more about because if you don't study then you're not going to do very well on like tests and quizzes.

Overall the various strategies contributed to the ways students prepared for tests and quizzes, whether that involved studying (usually newer material before the first assessment) or reviewing material (usually already covered material that needed reinforcing before a re-assessment).

**Clarify.** “Clarify” encompassed any way formative assessment made the learning process clearer because there was less confusion about what students needed to know and how to improve their current understanding in order to reach a higher level of understanding. For students, it was clear what they needed to improve on and where they were weak in their understanding of the material. The information about their understanding (or lack of understanding) guided their studying as it clarified what they were expected to know in the context of the assessment or activity.

Students mentioned how the individual written feedback provided them with specific information about the areas where they were struggling. For the students, the written feedback clarified which material they needed to review because they lacked understanding. Brooke reported:

Because it's like it's more specific [*sic*] than like if you just put a score on paper – the feedback actually helps you and you can have certain areas to study for. It kind of helps you there. Yeah.

Individual oral feedback allowed students to clarify their understanding of the material by asking questions and engaging directly with the instructor. JuanMa talked about his one-on-one interaction clarifying his misunderstandings in the class:

Uh, it's helpful. It is because then it's just you, you the instructor and then me as a student, and I can ask you questions and know that you're going to like answer the questions like on the spot and clarify everything. Yeah.

And Jared found that the feedback pinpointed exactly what he needed to improve on:

It just helps keep it fresh in your mind. It pinpoints the source of what you need to work on. It just...um...singles it out, tells... It just helps a lot just in my opinion.

By having the corrections and time to go over the material, students were able to move their learning forward. For Anastasia, going over the material twice made her understanding of the material clearer:

So when I do learn it twice and then I get to take the retake, it helps because then I know I understand it better and I get a clearer view of what I'm trying to talk about.

Students were also able to learn more about the material about which they may have had confusion from the beginning. Brooke learned more because the corrections clarified content objectives she was confused about before the test or quiz:

Well it gives you like a more like to tell you like...it helps you with a little bit more to learn about it. But then it's like it helps you like recap on what you know about it and it helps you get un-confused a little bit. Pretty much...

The written feedback, corrections, and retakes were closely tied together when surrounding a test or quiz. While students did have retake opportunities in other classes, they lacked the written feedback and corrections to clarify misunderstanding of material. The pattern in chemistry consisted of students taking the test, then receiving the test back within two days with written feedback in the margins indicating where students needed to elaborate or provide more detail in their responses to short answer or essay questions.

Students had time in class to read over the feedback and ask general or specific questions to the instructor. Usually there was some general all class review followed by time for students to work through corrections on a separate handout. Once students completed their corrections and felt comfortable with the material (within a given timeframe, usually a few days), they took the retake. By using the corrections and organizing the test in sections by learning target, students had a clear idea of what they needed to learn to move to a deeper understanding. JuanMa described his view:

Like normally teachers just tell you like if you get a test wrong, or if you need to retake a test just to study for it and like they don't tell you what the retake is going to have. So basically you study for the same thing you studied for on the original test. Sometimes you don't even get to like... I don't know, like study good for it because you don't know exactly what to study for. So this helps a lot because you know exactly what to study for.

Questioning also helped to clarify content that students did not understand. In JuanMa's case, the questions made the material clearer:

Um, they're helpful because you... Well they're helpful because... Basically it clarifies everything we just like don't understand, that's what they do. I think that's why you make them, to make everything clearer. Yeah.

In whole class discussions that incorporated lab questions, students were able to understand the lab better and ask their own clarifying questions. Anastasia reported:

I might not understand it as much if there wasn't a discussion because I like the discussions a lot because sometimes the lab itself is really confusing and I'm not understanding what we're supposed to do. And if you explain it afterwards it helps me understand what we're supposed to do. If it's like mixing chemicals and I'm not sure what we're supposed to do, it's nice to have that afterwards or if I can ask questions.

The self-assessment clarified the learning process because it broke down the material from the entire unit into clear, concrete, manageable pieces. Each unit had a list of seven to 12 learning targets. The instructor encouraged the students, after self-

assessing, to put the learning targets into two groups: those they felt confident about in their understanding and those they felt less confident about in their understanding.

Students completed this task and used the latter group of learning targets to guide their studying. Brooke found that it was easier and less confusing to study individual learning targets:

Like if you separate it piece-by-piece it's kind of easier for me because it's like I won't get so confused and I can learn one part at a time and study by that same thing what you need us to learn for that quiz basically. So yeah.

Each test or quiz was arranged into sections by learning target. After the assessment, it was clear to students what they needed to review or study because the structure of the assessment matched the learning targets. For example, if a student did poorly on the section about the structure of the atom, this was the learning target the student needed to review and study. By having the learning targets organize the test, Seba was able to clearly focus his studying on the areas where he lacked understanding:

I think it's a good way of grading and um... yeah. If the learning targets let you know what you know without any like confusion, you're just you see what you get on something then you know if you know it or you don't. It's...there's no confusion. It's really straight up with you. That's why I think it's good. And then if you know what you don't know then um, yeah, you can focus on that and learn it.

Each of the formative assessment strategies allowed for clarification of the material students needed to work on. By knowing exactly what they understood, they could guide their studying. Instead of being confused because it was unclear what they did not know, they were aware of what they needed to improve on and planned accordingly.

**Individualized.** “Individualized” related to how students view formative assessment as being specific to their personal needs and learning. The strategies involved make the learning experience personable and focus on the individual student.

Even though whole class feedback that often took the form of a review was given after a test or quiz, students still found individualized elements in this strategy. Brooke found the whole class feedback helpful when it pertained to the areas on the test where she, specifically, needed to improve:

Like how it’s helpful is because if it refers to you and what you need to be talked to about. Like it’s not helpful if it’s not for you because you probably already know it. So yeah.

Brian also thought the oral nature of the whole class feedback made it more personable:

I think I like this more because it’s more like person to person and then you tell me what I have to work on still.

While for Anastasia, oral feedback was only helpful if she was paying attention. She realized this was easier in a one-on-one format than whole class:

Yeah, it could be very helpful, but sometimes in the whole group you might not be listening, but if you were sitting in front of me I’d have a better...I’d probably listen more than if I was in a whole group.

The premise of individual feedback, whether written or one-on-one with the instructor, is meant to be individual and specific to the student. Jared felt the written feedback allowed him to focus on his individual learning goals:

Like instead of just getting to class, taking notes, you get your feedback to yourself and you get what you want to work on instead of the entire class, like... Somewhat like when someone says... Like you could say that people didn’t do well on learning target number three or something and it could be that you did good on it, or well on it, and then the rest of the class might not have but anyway except for a few people. But the feedback gives it...gives the specific part of it that you need to work on.

Other times having the instructor's individual attention helped students who learned at different rates and who needed specific questions answered. This was the case for

Amaya:

I think it's important because you [inaudible] like myself maybe working at a different rate than the others and I might not be understanding the same thing as everyone else, and so I think it helps one-on-one because then if I have any questions that maybe other students didn't ask in class I can go over them with you and you can help me understand better.

One-on-one time with the instructor permitted students to work through their frustration and confusion about the content. Brooke saw this as an opportunity to receive attention regarding her learning and emotional well-being:

I think it's helpful for me because it's like I could talk to the teacher and if I get confused I can talk to the teacher more about it and they could kind of help me get unconfused or unfrustrated about it.

The formative use of summative tests also allowed students to individualize their studying. Raj described students who learn at different rates, as well as how the opportunity to re-assess provided students with the chance to improve their scores:

Um, yeah I think it is because when you take... Like the first time you may get like a one or a two and then the second time if you actually study, go home, like try to learn it, you might get like a four or a five. Depends on each person, how they study and how they learn...how quickly they learn.

Seba noted how doing the corrections himself allowed him to study and learn more (rather than the teacher making the corrections for him):

I think it's important because it...I mean you do it yourself and then if you do it yourself you really remember what you studied. And I like doing that because I learn a lot more from doing it myself

When it came to questioning, especially when the instructor asked individual students the questions, students felt they were more aware of their own understanding.

Anastasia reported:

It helps because then you're not just asking one person, you're asking each individual person what they know and if they don't know it you can...it helps them understand what they're not knowing and they can go and learn it again.

Even though he felt on the spot because the instructor had to get to so many students in a short amount of time, JuanMa knew the instructor would come back around to check in on him:

Um, I think it's helpful but then again I feel like I'm kind of on the spot and I feel like I'm rushing to the question, but only because there's only so much...like a certain amount of time that you have to be with one person before you go to the next because we're just so many. But I think it's actually pretty good because like...like what you did is if we couldn't answer it you would go to the next person and come back to us and give us a chance. Like try and go back, see if we could like learn or go back to our notes or refer to something quick before you came back, and then we have it fresh in our memory and I guess it's good because I passed that. So yeah

In self-assessment, students recognized the "self" that was involved. Amaya likened the experience to a one-on-one with herself:

Um, I think it's kind of like a one-on-one with yourself so you can just kind of, you know, ask yourself like okay, well what aren't you getting, what do I need to understand, what do I need help with to better understand it so I can do good on the test.

Self-assessment updated students on what they needed help on. Emily enjoyed the ownership self-assessment provided:

Um, self-assessing myself is basically going to help me to know if I still don't get it and if I need to ask for help. And then it just...it's fun to do it myself instead of having somebody else tell me what I got. It's like what I do, what I don't get.

Students also used the self-assessment to determine how much they had to improve to get to a higher level of understanding. JuanMa found that through reflection he was able to focus his test preparation:

I think... I think it's more of a reflection, like I'd say I think I have a one on this one but I know I can get a five, I just have to like prepare harder for it. And I

think it's...it's helpful because then it just shows us like individually how much we have to prepare for like the test in order to get a five.

Students found that the formative assessment strategies individualized the learning process. Each student had different needs, but felt these needs were met, whether through written feedback, whole class feedback, one-on-one time with the instructor, or the use of learning targets. All of the strategies contributed to helping the students have an individualized experience within the larger classroom.

**Informs the learner.** “Informs the learner” described the way in which formative assessment provided information to learners that helped them in their understanding and progression forward in the learning process. Students were aware of what they were learning, what they had learned, what they needed to learn, and how they could get to a point of complete understanding.

During whole group feedback students found out about areas where many students needed improvement. Raj found that knowing about common mistakes and reviewing them was helpful:

You tell us like if... You just tell us the mistakes and then what are the most common mistakes. And then most people probably have that so they would just be like, "Oh, okay, I get how to do it now."

And Jared noted that during this time he found out about what he needed to go back and review in his notes:

It's helping with um, finding those parts that you are having trouble with and need to work more on, think more about it, look over notes about those.

Individual written feedback provided specific information to students about what they needed to elaborate or improve on. In short answer or essay questions, at times students had the correct idea, but needed to provide more in-depth explanation to

demonstrate deeper understanding. Brian usually did not usually provide an in-depth response to short answer questions on the test, and he explained that the feedback informed him of when he needed to give more detail in his responses:

Um, it tells me that I have to like be more descriptive about my answers and just putting down the obvious answer isn't enough, I should go into it and I should write more, like a whole paragraph.

The individual written feedback explicitly explained to students what they needed to work on, either by informing them of material they did not know or of material where they needed to develop their understanding. Brooke noted:

I like the written feedback myself because it's like I understand like what you want and like what I need to work on and like kind of stuff I got. I like the smiley face [inaudible] but...I also like the written feedback because it's just like, it tells me what I have to work on and what did I kind of do right and what I need more help on. So I like it. It helps a lot.

And by knowing what they were getting correct or incorrect, students could acknowledge their own understanding, as in the case with Amaya:

Amaya: But then again if I write something incorrect and you correct me on it, it helps me understand what I wasn't understanding from the start so I think it helps a lot and it's a good procedure. And then that you write feedback also helps a lot too then explaining the feedback helps too.

Amaya: Like right here you tell me what I need or what I'm not completing, or you're asking for a little more in depth. And I think that, like I said earlier, it helps reinforce what I've learned and what I haven't learned.

The information from the feedback offered a clear explanation of what students knew and where they needed to go. Seba provided a map analogy to discuss how the feedback informed him of his learning:

I mean well...I mean like you take the test and then maybe you got something wrong, and then it has the feedback but if it didn't, you'd just be lost, you don't know what's going on. But you have the feedback and then you can retake the test. So when I had the feedback, it's like the map. So you were lost before, now you have a map. And now it shows you what you need to get through to I guess

get to wherever you want to get to. So if you have that map you just get to whatever you have to get to, you learn and then you get where you are. And then you're able to take the retake, then you understand everything a lot more. So yeah, it's kind of like if you're lost in something and you get a map it's really helpful.

When working preparing for re-assessments with their tests, students found the corrections to be informative of their place in the learning process. Brooke noted:

And like the corrections understand like they tell me where I am, what I need help on, and they correct me even though I don't like to be corrected much. Like sometimes I'll understand it more when I'm going through the corrections than I am going through the test. So yeah.

Continuing with his map analogy, Seba talked about knowing what he had to get through and how knowing that information motivated him in his learning:

I think it was the...I think... Um... I think mostly it was the retakes because I mean you could see what you had wrong, and that just opens up a whole map where this is what you have to do, this is what you have to get through. Once you get through that you can retake it. And that, I guess, is really motivating to be able to have a retake and to see what you have wrong. And it motivated me to learn more about what I was doing and I did. I think that was the best, the thing that motivated me the most in learning.

The first test let students know exactly what they did or did not understand. JuanMa described this:

Um, I think the retakes is actually a really good idea because if you didn't get it good on the first test it means that you didn't like understand it,

During questioning, again students were informed about what they knew and had time to ask more questions. Seba reported:

Mm-hm, yeah, because it's like a test so it lets you know what you know but then at the same time if you don't know it you get the answer and then you explain to us why and everything.

And for Sarah, going over the questions provided information on what she would be expected to know for the test. She explained this as:

I think they're like legit questions because it's what we should know for the test.

When asked to self-assess, students were reminded of material that they had forgotten. For Amaya, she recognized that she forgot material and made mistakes, so they self-assessment acted as both a reminder and guide for her learning:

They also help, like help me remember what, like maybe if I've forgotten something or if I messed something up, it helps me again to evaluate where I'm at and yeah, and where I need to be – especially where I need to be. And if I'm messing up on anything then I can just look them over and then if I have questions about them I can just ask you.

By knowing which learning targets they did not understand, students were able to reach for an understanding of all of the learning targets. As JuanMa stated:

Um, well like I said, it helps us see how much more we have to understand or how much more there is left to understand in order to like completely like understand all of it.

Self-assessment also acted as an informative guide about the student's learning. Raj noted:

All of them, kind of. It kind of gives you like...it just gives you like a little space so that you know what you're doing. I mean it just guides you where you're supposed to be, tells you what you're learning.

And Max talked about using the quantitative scale to inform him about where he wanted to go with his learning, in this case from basic understanding (ex. one or two) to deeper understanding (ex. four or five):

Well...well they help me. They can like... I can see where I'm at on that subject and if I have like a one or a two I can see how I can then work it up to go to like a four or five. And yeah.

In general the formative assessment strategies informed the students about their learning. Each strategy provided something different to the student in the learning

process. Questioning informed students about where they were in the learning process. Feedback informed students about where they were and how to reach a deeper understanding. When used with self-assessment, the learning targets informed students about where they were with their learning and where they needed to go. And the corrections and retakes allowed students to close the gap in their understanding.

Across all of the strategies, students reported the strategies prepared them for future assessments, clarified material, individualized the learning process, and informed them about their learning. These themes appear to cut across formative assessment, regardless of the approach. While some strategies are more teacher-directed and others are more student-directed, they all appear to improve the learning experience for students.

### **Themes Overlapping Strategies**

The following themes overlapped across two or more strategies (e.g. theme emerged in whole group feedback, questioning, and formative use of summative tests). In the individual models, these overlapping themes are represented by semi-circles. Each strategy had at least one theme that overlapped with another strategy.

**Know what is wrong.** “Know what is wrong” came from a common phrase students said over and over again when talking about how feedback (both individual and whole group) and formative use of summative tests (corrections) were helpful. This theme described how students knew what they did wrong on a test or handout because there were clear indications of which part(s) of the responses were correct (usually from written feedback). For the students, knowing what was wrong seemed to be a unique part in the larger context of learning. Students adjusted their studying and made corrections

to the test when they knew what their mistakes were based on the written feedback. For Seba knowing what was wrong allowed him to move on and figure it out:

Well I think it's helpful because if you get the feedback then you know what you have that's wrong. So then if you know what you have... what is wrong, you can think about that and like, "Okay what did I get wrong and why did I get it wrong?" And then you can, if you really want to know you figure it out. And then once you figure it out then, yeah, you're just smarter, you know more about the subject and you feel a lot better because now you really learned this, not just think you learned it. Now you know you learned it.

Anastasia felt the feedback helped her understand what she was doing wrong in order for her to learn from her mistakes:

Anastasia: And when you give me feedback, it... like maybe if you just tell me it's wrong I don't know what I'm doing wrong, and when you give us feedback I understand what I'm doing wrong and that helps a lot.

Anastasia: It helps because then when I do take it again, um, I see what I did wrong and I learn from my mistakes.

And Brooke noted that when looking at her tests and working on corrections knowing what was wrong allowed her to go back and make changes:

Like for me the corrections help me see what I got wrong and how I could fix it. And like when you have to take notes about what you got wrong and then like you go over the corrections. And then you like... sometimes you understand, like me, I understand why I got it wrong so then I can go back and fix it. Usually, so it's kind of like that. Like if I get, like last time I had like a low score and I had to go back and fix it and usually I'll get higher than it. So it's like helps me a lot. So I like it.

For students, understanding their errors provided a specific kind of information about their learning. This was helpful as they proceeded with their studying and learning progression. For them, the feedback and corrections let them know why they got something wrong and allowed them to correct those mistakes. They perceived this feedback as more informative than a mark or check that simply denoted an error.

**Positive internal feeling.** “Positive internal feeling” related to the feelings students associated with self-assessment, questioning, and formative use of summative tests. These feelings were intrinsic and related to confidence, stress reduction, and reassurance. Students had positive associations with learning and making mistakes. For Amaya, the learning targets gave her confidence because she could return to them and check for improvement:

But like I said, the learning targets made me feel more confident because if you ever have problems you can just go back and look at them. And it helps you evaluate where you're at so down the road you can go back and see how much you've improved and how much you've learned.

When it came to questioning, Amaya also felt a level of reassurance regarding her learning:

Um, I think it helped a lot because then you're helping us reassure ourselves that we know what we're talking about and we know what we're working with, rather than just you know like maybe looking on to a partner and see what they are doing instead of you know trying to figure it out for yourself.

Raj focused on the act of doing something by himself that provided the self-confidence:

But when you do it by yourself I think you like gain self confidence that you know how to do it instead of being like, "Oh, I don't know how to do it. I'll just get it off the board."

For Seba, the re-assessments offered a less stressful learning environment that helped him in his learning:

And then there's the option to retake the test. I think that's really good. It's really helpful and it's a lot more...it has less stress. Like if you don't know much about something and you're taking the test and you're like, "Oh I'm going to fail!" you know, there's still always the option to retake it. So that takes a lot of stress out of you and it makes you want to learn things better. So I think it's really helpful.

JuanMa described feeling confident when he was ready to re-assess:

And then we assess when we feel like we're ready to...like when we feel like we're confident enough to pass the learning target

And then, JuanMa felt pride after he showed progress on the re-assessment:

And then I guess you kind of feel proud of yourself when you get good on the retakes because you know...you actually learned more

When it comes to self-assessment with learning targets, questioning activities, and retaking the test, students had a positive association with learning. The key word here is learning, as students did not emphasize grades or points, but the feelings they had about learning. Students' experiences helped them develop positive internal feelings both leading up to and after an assessment. Overall the strategies enhanced their confidence as they moved forward in their learning, despite moments of failure or confusion. These positive internal feelings are closely tied with the next theme, second chance.

**Second chance.** "Second chance" dealt with having another opportunity to learn, try again, or progress forward with the material. The learning did not stop with a single assessment or question. Rather students were able to keep their learning moving forward and try again. They had the opportunity to continue to work hard and put forth effort—particularly with whole group feedback, questioning, and formative use of summative tests. For Anastasia, hearing the information again helped her with her understanding:

Anastasia: Um... It helps me by um, giving me that second chance um... Yeah. It helps that, like I said before like, learning it once sometimes it doesn't click and then again it helps.

Anastasia: I like that because then when I take the quiz, um...sometimes if it's really hard, just listening to you explain it, maybe I'll understand something that I didn't understand before when you first went over it. And then I get it better the second time usually.

During the questioning, JuanMa had time to go back to review his notes in between instructor questions because his own responses informed him of what he had not learned:

...Like what you did is if we couldn't answer it you would go to the next person

and come back to us and give us a chance. Like try and go back, see if we could like learn or go back to our notes or refer to something quick before you came back, and then we have it fresh in our memory and I guess it's good because I passed that. So yeah.

The entire concept of doing corrections on tests with the opportunity to retake naturally lent students to think of second chances since normally a summative test meant a finite end with a single chance. Students viewed themselves as dynamic learners, they were capable of learning more and demonstrating that learning with another opportunity. About the option to re-assess, Amaya said the following:

I like that option because it gives you the opportunity to like, if you didn't get something it gives you the opportunity to study again, reinforce it more (because you've already had previous studying) and so it gives you a better opportunity to do way better on the test. Like you know you can do better on it, you just want another chance. Yeah.

If the opportunity to retake a test or review the material again was available students were likely to take advantage of that opportunity. For some students, they recognized that their learning kept progressing forward. Anastasia needed more than one opportunity to learn the material, in order to feel she really understood it:

Uh, I do feel like when I take it the first time I may not know as much as I do the second time. And that when you do go over it in class it helps uh, that it clicks. Because sometimes I have to... I can't just learn it once, I have to learn it twice. So when I do learn it twice and then I get to take the retake, it helps because then I know I understand it better and I get a clearer view of what I'm trying to talk about.

For Brian, the first time he took an assessment may not have represented what he actually knew because of test anxiety:

Uh... I like that idea because usually I choke up on like the first time I take a quiz, and then the second time you just know like what you have to work on and you go for like what you want to...

For Brooke, Or personal factors outside of her control (i.e. home life) sometimes prevented studying:

The option to retake quizzes, like I like it because sometimes I don't do so well, especially if it's a Monday and it's a test because over the weekend I don't study because I have things to do. Like I like it because if I get something wrong and just because I don't understand it or I just forgot something I can reassess. And it's just that it just makes me feel good that I have another option if I mess up once then you have the option to do it again.

Using summative tests formatively took into account the way teenagers learn and their experiences outside of the classroom (social and home factors outside of their control). It seemed to provide them with more control in the classroom knowing they would not be “judged” or assessed only once. Students were not penalized for other factors outside of their control. JuanMa expressed this idea of fairness, and how having a second chance to show understanding was a fair practice:

Um, the corrections... Well the retake I think it's really good because um, not a lot of teachers offer this, like the retake. Sometimes a lot of them do know but when they don't it's not that fair because we don't get like a second chance.

For students, having a second chance to show what they knew and taking the time to learn more in between assessments was important. They recognized that they learned things at different rates and needed reinforcement to ensure their understanding. This seemed fair and refrained from penalizing students when they were not ready to properly demonstrate learning, whether those factors were under their control or not.

**Deeper understanding.** “Deeper understanding” related to a more in-depth grasp of the material. Through whole class feedback and questioning, students developed more of an understanding because they were aware of the learning goals. During whole class feedback, the review offered another opportunity for students to interact with the content and get to the next level of understanding; as noted by Anastasia:

Yeah. Learning it a second time is usually more helpful because sometimes it doesn't click the first time and I don't understand it, then the second time I get it to a higher level of understanding.

And Seba reported how simply hearing the information again allowed for some students to learn more:

...But if everybody's paying attention then hearing it, some people learn better by hearing, so when you hear it sometimes you learn it more and you can understand more. Yeah, I think it's good as long as everybody pays attention.

Of course the conditions of the class, focus and paying attention influenced what students heard and learned.

When involved in questioning activities, either in small groups or large groups, students' awareness of the material and how it related increased. Both Jared and Seba talked about being more aware of the learning process:

Seba: Mm-hm, because once you asked the questions, like it made me think about how it all fits together. And then once you figure out how it all fits together you can understand it real good.

Jared: I think it was actually a great idea because it makes you start thinking about it instead of just looking through a book or something, just looking for answers. You actually had to think about it and just elaborate and study your notes before you asked us the questions. So I thought it was a good idea.

Questioning also led to a deeper understanding because of the types of questions proposed to students. Seba noted that he started to answer more of the reasoning questions:

Seba: Yeah, definitely. If they weren't there there wouldn't be...you wouldn't learn as much as far as why. You'd learn what it does but not why.

Instructor: Okay.

Seba: That's what I think.

Instructor: So what's the difference between what and why?

Seba: Well what, it's just you know what happens, you know...like you can know... Like let's say it's raining, but you don't know why. It just... If you know it's raining, you don't know why, you don't really understand rain, or anything like clouds or anything about that. So you have to learn... You have to understand why to really learn something at a deeper level because you can see what something does, but if you don't know why then you don't really learn it, you just know it. You know.

Through the questioning, the information became deep-seeded, rather than surface information; as Jared reported:

Um, it basically helped to get further in depth in my mind so I could remember it better. And then just so I could just have it there kind of in my mind forever, and I probably will from now on.

Through strategies like whole class feedback and questioning students felt they developed a deeper understanding. When in the large group, students were able to get the extra review that they needed, and therefore, another interaction with the material that allowed reinforcement of the concepts. During questioning, the probing seemed to get them thinking beyond the basic knowledge and making connections within the material. Overall these strategies pushed students' learning forward, specifically from a basic level of understanding to a deep level of understanding.

These four themes saw overlap in certain formative assessment strategies. Both whole class and individual feedback informed students about where they were making mistakes and not grasping material. Whole class feedback, through its overall review of the material, also helped students develop a deeper understanding of the material and let them know that learning happens over time in more than one instance. When students were able to make corrections, they knew where they were making mistakes and could feel good about their learning because they had another opportunity to show their growth. Questioning provided more time for students to go over material and increase their

understanding, which in turn helped them to feel more confident. Self-assessment, like questioning and the correction/retake process, also allowed students to feel good as they checked their own progress in the class. Students had both cognitive (deeper understanding) and emotional experiences (positive internal feeling) because these strategies allowed them to keep the learning process moving forward (second chance), especially when they knew where they were not completely comprehending the material (know what is wrong).

### **Themes Unique to Individual Strategies**

Only three of the implemented strategies had unique themes. On their models the unique themes are represented by hexagons. In this section each of the themes is discussed by strategy.

**Questioning.** Within the strategy of questioning, three unique themes emerged: “involved in learning,” “social,” and “time for questions.” These particular themes all had a more interactive nature to them. This is not surprising, considering that questioning was the only activity that required interpersonal communication with two or more people.

***Involved in learning.*** “Involved in learning” had to do with the student taking an active role in the learning process. Especially in activities where the instructor visited students working in small groups or individually, students felt that it was an interactive experience oftentimes embedded within a hands-on activity, rather than receiving information passively (i.e. lecture style). Jared spoke about how activities with questioning got students engaged:

I think it helps a lot because it gets the kids engaged – it gets us engaged I guess. It gets us thinking instead of just writing answers on paper. It makes us actually use our mind.

Ebony realized she was going to have to answer questions about what she knew, so getting involved was a way to prepare herself:

It was helpful because at first I didn't understand, I was like, "What?" And then as my partner was telling me like you're going to have to answer questions and you're going to have to know this is electrons, neutrons, and stuff. And I was like, "Oh, okay." And as I did it...as I did it more, I understood it more with the beans.

The questioning strategy allowed the students to feel involved in their learning and provided information about progress to both the student and the instructor. Amaya noted that her involvement reinforced what she learned:

I think that also helps a lot with the whole evaluating situation because then you're reinforcing what you've already learned and you just go over it with the class, which helps you get more involved, rather than just with your group. And the activities help a lot because you're also getting involved again rather than just sitting and listening to a lecture.

Questioning allowed the students to get more involved in the learning process. They were aware of the expectations and made adjustments to their studying as they responded to questions.

***Social.*** "Social" encompassed anything where the students were able to interact with each other, either in small groups or a whole class discussion after a laboratory activity. Brooke thought questioning in the large group allowed the class to learn from each other (especially if students were asking questions):

Well I like it because it's like helps me understand the more the bad better you know. And it's like helped me resummarize what I did and how I did it. That's kind of like I like the post lab questions and the discussion, because you get to hear what everybody else thought and see like kind of had the same or if they had it different and you can kind of learn more from other people to with their different answers to their questions.

And Raj talked about how listening to others' questions and responses, students who were too timid to raise their hands could have their own ideas confirmed or challenged:

Um, yeah, I think it was because when you do it together you all...if you do it together like someone that doesn't know something and someone that raises their hand and tells you the answer, they'll remember the answer because they're too...they don't know what the answer was. Or if somebody knew the answer but didn't put their hand up because they weren't sure about it, and somebody else put their hand up and they knew about it, then they would know they were right or they were wrong. So it kind of helps in both ways.

Seba reported that by exchanging ideas and sharing responses students learned more and pushed them to think more about the lab:

I think that's fine that we use it because after we do something it's always good to go back to it you know. And yeah, if we do a lab and then we have questions afterwards and we all discuss it as a class, I think we're all going to understand it better. And like some things we do a lab and then it happens and we don't know why it happened, but then the questions ask you why did this happen, why do you think, and then we write what we think that makes us think and then you tell us the answers and then we discuss it. It's good.

Through social interaction students were able to exchange information, share ideas, and learn from each other. While the instructor initiated the questioning to engage the students to think about what they learned and knew, oftentimes in large group settings, students generated other questions that pushed the learning and understanding. The generation of questions by students for learning is discussed more in the next section.

*Time for questions.* And "time for questions" expressed students' awareness that they had the time and space within a class to ask their own questions, either to the instructor or in a discussion with other students. Students also have time to get a response to their questions. JuanMa liked having the opportunity, especially if he had any doubts about the material:

Um... Yeah, like you give us a chance to ask questions that come up within us, and you help us like understand it better if we have any doubts on it...or the subject.

Oftentimes students had the same questions. By having time to ask questions, Anastasia

noted that common questions surfaced:

I have a... Sometimes when you're doing the lab you get lots of questions, and then when we're in a group maybe someone else has the same question and then everybody else is learning too, not just you.

Student questioning was not restricted to knowledge seeking, but also included ways to go about answering other questions on their own; as Amaya pointed out:

And so you come around and ask us questions and if we don't know then we can ask for the answers and ask for ways to find the answers on our own. So I think it helps a lot.

**Self-assessment.** Five themes emerged that were unique to self-assessment.

These themes included: "break it down," "focus," "evaluate self," "sets goals," and "prevents use." While "break it down" discussed the perception of self-assessment, "focus," "evaluate self," "sets goals," and "prevents use" talked about the ways students used or struggled with their use of self-assessment.

**Break it down.** "Break it down" represented the idea of a large chunk of information that students were expected to know broken down into manageable pieces to guide their studying and to help them stay on track with their learning. As Amaya noted, the learning targets used in self-assessment broke down the learning process:

Um, they help a lot to break down the learning process for me, and they help me learn a lot about the atom.

Kamal talked about the ease with which one can go into depth with small parts of information that lead to an understanding of the whole:

Well if you learn...if you learn more parts of it at a time you'll probably be able to...you go more in depth into it because...you go more in depth into it because you just...because you know every single part so well you will know the whole entire... It's like if you know the...every single part of one thing, then you will know the whole thing better to your knowledge. That's pretty much what I think.

For Anastasia, the break down of the criteria assisted in her actual assessment and

possibly alleviated some underlying text anxiety:

Uh, especially in quizzes, because I'm not the greatest at quizzes, if you break it down I'm more likely to think about that instead of the whole test because it's broken down and then I get... I can read one question for Learning Target One and understand that, and then move on and understand that too, instead of one big quiz.

Students struggled with a large amount or "clump" of information. Brooke elaborated on how by using the learning targets she was able to guide her learning step-by-step—despite frustration:

Well I actually liked it. It's not just that I liked the teacher, it's because I learned more than I probably could have with the learning targets than I could have without it, especially because I get frustrated when there's like large clumps and unorganized...because I like it. It's just certain things you know, like I like the learning targets just because it's just all organized and then if it's like all clumped together I get really confused quickly, and frustrated. Because when I'm confused I get angry and get frustrated and then I just want to give up. Then with the learning targets I just don't give up because it's like...it's more organized for me. So yeah. It's not that hard, the work.

By self-assessing using the learning targets, which are the objectives written as manageable pieces, students felt comfortable and easily monitored their progress, even through points of confusion and frustration.

***Evaluate self.*** "Evaluate self" described how students explicitly used self-assessment to determine their understanding. Here they used self-assessment to evaluate what they learned using the learning targets. Amaya viewed the self-assessment as a one-on-one with herself about her understanding:

Um, I think it's kind of like a one-on-one with yourself so you can just kind of, you know, ask yourself like okay, well what aren't you getting, what do I need to understand, what do I need help with to better understand it so I can do good on the test.

And for Brooke, being able to self-evaluate was important because she felt that she provided the best assessment of her understanding:

I think so because it tells me where I'm at because only you can tell you where you're at. The teacher can kind of put you where you're at, but it really depends on what you think about how far you are and how much you understand because only you know what you understand. So yeah.

Students use the learning targets to guide the ways in which they evaluate their understanding and their learning progression.

**Focus.** “Focus” explained the ways in which self-assessment allowed students to narrow in on what they were to know and study, especially as it related to an assessment. For Seba and Brooke, they were able to focus on the material they did not understand when studying (and shifted focus away from material they did understand):

Seba: Yeah, it's helpful. I think it's better than just doing a bunch of work and then you don't know what you don't understand. Here, it has everything written out that you have to learn and how good you are at it. So I think it's good because you can focus on what you don't understand.

Brooke: ...it's just it helps me with like focusing more. Like if I need like one learning target I'll focus more on that one than all the others. Like if I don't understand one I'll take more time on it.

And Jared talked about how the learning targets specifically can keep students focused on the material:

...But I think it will help people like stay on track with everything regarding anything that learning targets will use

Students used self-assessment with the learning targets to focus on what they did not understand as well as a general guide for the required material.

**Sets goals.** “Sets goals” described how students used the learning targets to set goals for themselves about what they needed to learn and study in order to do well in class. It provided structure for students. This was particularly important to Raj, to set a goal for himself when studying and learning:

But I mean, it helps I guess a little. I mean you see what is right in there, that's

basically what the goal is to get a...like you want to set a goal for you and if you pass it you achieved it, if you didn't then just work harder and get there. That's how I see it.

Certain students perceived self-assessment (with the learning targets) as a step-by-step plan to evaluate themselves, and Raj clearly identified them as mini-goals in order to achieve his desired score or grade. According to Raj, the learning targets told him what he needed to know, but he did not use them to determine his own place in the learning process.

*Prevents use.* Sometimes students did not use self-assessment or used it in a way they thought was different than its intended use. As a result, the theme “prevents use” emerged from the data. Some students struggled with actively engaging in self-assessment because it was unclear how to do it or they got confused (although they used the learning targets in other ways as noted by the previous themes); even after practice their usage of self-assessment was inhibited by lack of confidence or confusion. Raj reported the following perspective:

I think it's all of them. Some people don't know how to use the scale. Some people don't understand what the like one, two, three, and four, and five mean. And some people just don't understand like what it's all about I guess.

Brooke talked about her own frustrations with mixing up the learning targets and getting confused when interpreting her own understanding:

... So I really do get confused because it's like I'll confuse it with like...I'll mix like a certain learning target with the other one and then I'm like...and then like I had to go back and I get so frustrated...So it's kind of like I get confused when it comes to certain learning targets, sometimes they look the same to me. So yeah.

Other students did not feel confident in self-assessing themselves. Anastasia reported usually thinking poorly about her learning and hinted at preferring teacher confirmation regarding her understanding:

I don't like it that much. I mean I don't feel that it's very helpful either because I tend to think really bad about my learning and I don't think I'm as high as a level as I really am. So I know... And then... I don't know, it just doesn't help me to think that. It's nice to know exactly where I am instead of where I think I am.

Seba worried that he assessed himself too high and this inaccurate assessment could be a problem later on:

Because it's me grading it and I just don't like sometimes I don't know what I know about something. Like I think I may have it good and then I put like a four or a five or something but then the teacher does this and that and then you listen and then you're like, "Oh, I don't know that much about that subject." So I don't think it's very accurate for you to self-assess yourself, that's why I don't think it's helpful to me.

These students explained reasons that prevented them from using or frustrated them when engaging in self-assessment. Raj had his own system that he preferred, more related to traditional grading:

Raj: I just don't think they are because I don't really use it that much. I just know, I think I have it in my head mentally, that's probably why. I like know what I want to get then if I don't get that then I just try it again because I'll have it down in my head already and I know what I want in like score-wise, in like one through five, I know what I want to get in there.

Raj: ...I mean I think I just look at it as like if you get a five that's like an A, if you get a four that's a B, C...or three is a C and so on. I think I just look at it like that instead of actually like a five and like how it's supposed to be like...yeah.

The previous year, Jared had a poor experience with another teacher and this prevented him from using the learning targets:

Jared: It's just um, last year I had a teacher use the learning targets and didn't really give me a definite grade. So until like the time that we were going to be...until we got report cards, which kind of like led me...led me off, so I couldn't really tell my grade and try to fix it.

Jared: Um, they just...they just um didn't like tell me when I needed to like urgently try harder and harder instead of like you're at a C or something you need to get higher, you need to start doing way better instead of like, "Hey I have like a bunch of fours and a one, I need to fix that one or I'm going to fail," which is kind of weird.

Similar to Raj, Jared preferred the traditional letter grading system that focused more on points and percentages than an assessment of learning. Amaya noted, however, that the usefulness ultimately comes with the commitment of the individual and not the process itself:

I think they're really useful as long as you're using them in the right way. If you're not really paying attention to them and just blowing them off, then they're not going to be very helpful. But I think it depends on the person.

Even though students sometimes had a lack of confidence or aversion to the system of using learning targets for self-assessment, they never completely rejected them. In the case of Raj and Jared, they overlaid this system onto a traditional system. And other students like Anastasia, Seba, and Brooke still found them useful despite setbacks and frustrations.

**Feedback.** Under the strategy of whole class feedback, the only unique theme that emerged was “not used,” which discussed the reasons why students did not incorporate or integrate the feedback.

**Not used.** While there were aspects of whole class feedback that students thought were helpful, sometimes they did not use the information that was presented. Certain students already knew the information that was being presented or reviewed. Brooke and Brian mentioned not finding the feedback helpful when they already knew what was being covered:

Brooke: Like how it's helpful is because if it refers to you and what you need to be talked to about. Like it's not helpful if it's not for you because you probably already know it. So yeah.

Brian: Well there was some stuff that I already knew that wasn't very helpful but at the same time it was because I could write it down again.

Other times students did not know the material, but the feedback that was provided was too general. JuanMa talked about how the information was more general about the entire class' performance and that for him, more specific information would have been more helpful:

Um, well when you speak to the class it's just like it's typically more of a generalization as of to how the class did. It's not very specific as of to how one single student did. But it's helpful because then we know what the class has to work on like together. And like maybe all the students got that question wrong, or maybe the majority of them did. And there we know like who does know something and who doesn't. Yeah.

In certain situations the whole class feedback was not applicable, because the information only applied to part of the class and the individual written feedback turned out to be more helpful; as Brooke and Jared pointed out:

Brooke: Oral is okay but some people just like the feedback better on paper because it's like you understand more because sometimes what the teacher will probably say is something that doesn't refer to the whole class, sometimes it's some of the class. But I guess it's okay I guess, it's kind of like the [inaudible] it helps other people too.

Jared: Like instead of just getting to class, taking notes, you get your feedback to yourself and you get what you want to work on instead of the entire class, like... Somewhat like when someone says... Like you could say that people didn't do well on learning target number three or something and it could be that you did good on it, or well on it, and then the rest of the class might not have but anyway except for a few people. But the feedback gives it...gives the specific part of it that you need to work on.

Even though students talked about instances in which they did not use the whole class feedback, they still listened and had valid reasons for why they did not use this information. If this was the case, most of the students defaulted to one-on-one feedback or the written feedback directly on the assessment.

The findings in this section provide an overview about the experiences students had with each of the different strategies and the unique themes as well as common

themes that emerged. Each of the themes seems to touch on the various aspects of the students' lives: cognitive, social, personal, and emotional. For them the strategies allowed for learning in an individualized continuous fashion that provided emotional support and engaging, social moments. At other times the strategies informed them of their mistakes and their own assessment of their development in the learning process. The implications for the student perceptions and experiences with the different approaches of formative assessment are discussed in more detail in the next chapter.

## **Chapter V: Discussion, Implications, and Suggestions for Future Research**

As outlined in Chapter I, the purpose of this study was to address the dearth of understanding of high school science students' perceptions and uses of formative assessment in urban areas. Although there are many studies that focus on the implementation of formative assessment from the teachers' perspective (Bell & Cowie, 2001; Furtak & Ruiz-Primo, 2008; Ruiz-Primo & Furtak, 2007; Sato, Coffey, & Moorthy, 2005; Yin et al., 2008), very few focus on students' experiences with formative assessment. Those few studies (Cowie 2005a; Cowie, 2005b) that have been done have happened outside of the United States with high-achieving honors students in suburban settings.

While some researchers (Brookhart, 2003; Cowie, 2005b) have argued that understanding the ways in which students use formative assessment is important, these types of studies have not been pursued. In fact, very few studies have focused on formative assessment in the classroom lately; much of what has been published in the last few years has focused on the theoretical basis for formative assessment (Andrade & Cizek, 2010; Black & Wiliam, 2009; Coffey, Hammer, Levin, & Grant, 2011). In order to understand formative assessment and the way it functions in the classroom, it is imperative to understand the experience of the primary target of formative assessment: students.

This chapter will begin with a discussion of the major findings regarding this study. The findings are organized by formative assessment strategy followed by some broad conclusions from the data. Lastly, I will describe implications for science teachers and suggestions for potential areas of research related to this study.

## **Discussion of Major Findings**

The study aimed to investigate the ways students used formative assessment and their perceptions about its role in their learning. Students' experiences were examined to determine how they translate formative assessment after implementation. Overall, students had positive experiences with formative assessment and expressed different ways of using it that had a variety of benefits.

### **Self-Assessment**

Self-assessment involved students taking the time, either on their own or with the guidance of the instructor to reflect upon their learning and understanding. Students used self-assessment to evaluate themselves and to set personal learning goals. The data shows that students felt that they knew what was going on in their learning process, where they were doing well, and where they needed to improve. Specifically they were able to focus their studying strategies because the learning targets provided clear expectations and students used them to guide how they organized what they had learned. They could prepare for upcoming assessments in a way that was individualized to their studying needs.

Benefits of self-assessment emerged when students were using the learning targets. Students expressed that they had a clear idea of expectations for each unit because the material was broken into manageable pieces. Students used the learning targets to focus their studying and set goals for learning. This supports earlier findings by Andrade and Du (2007); they found that students were comfortable self-assessing when they knew the teacher's expectations due to the rubrics and checklists that acted as a guideline.

Students used the criteria provided by the learning targets to inform them of what they knew and what they still needed to know. They knew where they were on the scale of understanding and could guide their studying accordingly in order to close the gap between their current knowledge and desired knowledge. As a result of this awareness, both in terms of expectations and understanding, students felt their confidence build and experienced a less stressful learning environment. These findings resonate with the benefits of increased motivation and decreased anxiety that students reported about self-assessment in Andrade and Du's study (2007).

Although students used self-assessment to evaluate themselves, they relied on a qualitative understanding of their knowledge and learning. When students were asked to use a scale or quantify their learning, they did so informally, not as an act of self-grading (Sadler & Good, 2006). It appeared that students struggled with the process of assigning their understanding somewhere on a quantitative scale. They were reluctant to self-assess in this way or were prevented from self-assessing because they did not feel as confident or were unclear how to evaluate themselves. This supports Hanrahan and Isaac's (2001) findings about how students had difficulties when they were unsure of the standards and could not be objective about scoring themselves. Students had only been using the scale for self-assessment for a few months; with more time and practice, they might have felt more comfortable and confident about the process. Andrade and Du (2007) noted that students had positive experiences with self-assessment provided they had sufficient practice.

**The “anti-clump” factor.** Based on the statements of many students, one of the most useful outcomes of using the learning targets was that they were able to break down a large amount of information, a “clump,” into smaller and more manageable pieces. Students expressed confusion when material was presented all together and preferred the segmented presentation of the learning targets. By having the criteria clearly explained, students were clearly informed about what they were being assessed on.

In summary, students used the learning targets to organize information and content they were required to know and were able to break down large topics into smaller pieces that were tangible for them. Students were able to pinpoint exactly what they were expected to know and focus their studying on specific areas.

### **Formative Use of Summative Tests**

Formative use of summative tests involved students looking over their tests using the learning targets, and then taking time to make corrections in order to prepare for a retake. Students recognized some immediate benefits from using assessments formatively. It was clear to them what was wrong and they used this information to study and prepare for future assessments. In their mind the learning took on a fluid quality because they had a second chance. Having an opportunity to reassess or review the material removed any finite qualities from the learning process. This was especially important for students who learned at different rates than the majority of the class or had external conflicts that were affecting their learning or studying. And for some students the opportunity to use assessment formatively generated a positive association with learning; they saw making mistakes as part of the learning process, which in turn enforced a growth mindset (Dweck, 2000).

## **Questioning**

Questioning engaged students either one-on-one with the instructor or in whole class discussions following a laboratory activity. Of particular interest was that questioning was the only strategy where students talked about interactions with other students. Students enjoyed the social aspects that questioning provided either in small group or whole class settings discussions. This was a time to exchange information, learn from other students, share answers and ideas, and have conversations that invited a variety of voices. Also, questioning allowed for more positive teacher-student interactions. Students reported that they were more involved in the learning, especially when they were doing interactive or hands-on activities that involved questioning. Students recognized that they were active participants in the learning process, rather than passive participants, as would be the case in a lecture or traditional assessment format.

The teacher developed higher order and recall questions to gauge students' grasp of the material. During this exchange, students were able to ask questions about what they did not understand in the context of the learning goals they were trying to reach. When discussions or activities called for questioning, students felt they had the time to ask questions within a comfortable environment that invited questions. Students could engage in dialogue with the instructor or other students, and thus, clarify any confusion. This was particularly important for new material with which students had little to no prior experience in previous science classes.

William and Thompson (2008) also outlined how the effective use of questioning by teachers elicited evidence of learning by students. In this study, students were also able to use the information from questioning as evidence of their learning. Students

noted a deeper understanding of the material through the use of questioning. This could be because the questions raised awareness about the students' knowledge and because they encouraged higher order thinking, as was the case with post laboratory questions. Because questions followed another activity (i.e. post lab questions) or were embedded in the activity (i.e. instructor visiting small groups), students felt they had a second chance, or more than one opportunity to be exposed to the content. If they did not answer something the first time, either because of confusion or lack of familiarity with the material, there was another time later in the lesson for them to respond to questions to clarify their understanding. In summary, questioning afforded students a different type of assessment that was both interactive and informative.

### **Feedback**

Feedback was either presented to the student on an individual basis or to the class as a whole. In both contexts, students felt that they knew what they were getting wrong and where they were making mistakes. Feedback clarified what students needed to know while also preparing them for the next test or the next draft of a paper.

High quality feedback has been shown to have a powerful influence on learning and achievement, but in order for that to happen the feedback needs to relate to the specific task and match the needs of the student (Hattie & Timperley, 2007). In this study, students felt strongly that their needs were being met with individual feedback, whether written or verbally, one-on-one. They had an overwhelming response about the individualized nature of the strategy. The feedback was specific to the task, guiding them in the learning process, making learning personalized. The information provided during feedback made it clear to each student what he or she needed to work on, revise,

or change. Like the learning targets, the feedback students received cleared up any confusion regarding the expectations and they were able to focus their attention on studying material they did not know.

Whole class feedback had benefits and drawbacks. In the whole class format, students felt that the information pertained to them only in certain situations. They tended not to use the feedback unless it related to parts of the test they got wrong or areas where their understanding was weak. The reasons for this were usually because they already knew the material being presented, what was being presented did not apply to what they needed to know or the explanation was not specific enough.

When the whole class feedback did apply to students, then they thought they developed a better understanding of the material, as they were able to go over it again to reinforce the content they did not grasp the first time it was taught. Because this type of feedback usually involved a review of material, students felt that by being exposed to the material in another format, they developed a deeper understanding than before. Students also had a grasp of what they and the other students were getting wrong on the test. They used this information to guide their studying. In this way, even though the feedback was delivered in a large group, students found it was individualized to their needs. This agrees with Hughes' (2011) suggestions for maximizing learning through quality feedback that differentiates correct and incorrect responses while also informing students about how well they are performing on a task.

### **Conclusion**

This study resulted in a better understanding of the ways students perceived formative assessment in a secondary urban science classroom. The following section

presents some broad conclusions. As formative assessment is being pushed and addressed as a necessary part of assessment in the Framework for K-12 Science Education (NRC, 2012) and the National Science Education Standards (NRC, 2001a), the findings from this study help in understanding the ways in which formative assessment assists learners and gives value to students' experiences. This insight into how these different strategies can be used or modified to allow for student learning, engagement, and motivation can help both researchers and practitioners as they work toward scientific literacy for all.

### **De-Mystifying the Learning Experience**

The findings from this study shed light on what happens between teachers and students, and the interaction between teaching and learning. Formative assessment strategies clarify how students perceive the ways they engage in the learning process. Students repeatedly talked about having a clear understanding about what they were expected to know, learn, and do, which suggests that oftentimes they do not know what they are supposed to know. Poor performance is associated with a mismatch between students' and teachers' conceptions of the learning criteria (Hounsell, 1997) and students can only succeed in learning the criteria if they understand the criteria (Sadler, 1989). The poor alignment of teachers' expectations and students' understanding of those expectations may have accounted for some of the frustration or feeling of being "lost" that students talked about in this study. Expectations were clear through the use of learning targets, which provided a clear set of criteria in student friendly language. Students were able to use the objectives to guide their studying and assess their understanding. These same learning targets were used by the teacher to effectively

communicate the goals of the class to students, to guide the structure of the quizzes and tests, and to allow students to reflect on their own understanding.

### **Growth Mindset**

In her work on student motivation, Dweck (2000) talks about performance goals and learning goals. Performance goals focus on a student's ability. Students who focus on their ability tend to have a fixed mindset and believe their intelligence is fixed.

Students who focus on learning have a growth mindset and believe they can change their intelligence with hard work and effort.

The learning targets provided students with learning goals. And the feedback they received focused on what they had not learned, not on their ability to do the work.

Students recognized that in order to completely understand the material they had to review it or learn it more than once, especially if they wanted a deeper understanding.

Some students even described the frustration with the learning process, but the students talked about the personal rewards associated with learning. These positive internal feelings included confidence, pride, and general well being because the formative assessment strategies attended to the individual learning experiences and individual rates of learning.

### **Accessible**

At a time when equity and access are at the forefront of the goal of achieving science for all, (NRC, 2012), formative assessment allows students to have access to learning science. Because of the individualized nature, students felt that they were going to succeed in the class, which was important considering the variety of abilities. Students also received encouragement throughout the learning process that guided and motivated

them. The encouragement was specific to the needs of each student, as some were less intrinsically motivated than others, and therefore received more encouragement when they needed it.

Students of color and students of poverty traditionally have not done well in science classes (Atwater, 2000; Edmin, 2011; Lee, 1999). Although science includes difficult concepts, like any subject, the way the material is taught makes it appear more difficult. For example, engaging techniques like inquiry have been shown to be effective in improving student achievement and developing positive attitudes toward science (Kyle, Bonnstetter, & McGloskey, 1985; Rakow, 1986; Shymansky, Hedges, & Woodworth, 1990). Formative assessment also engages students by asking them to think about their own learning, in conjunction with feedback and clear learning criteria, with the goal of moving their learning forward.

### **Closing the Gap**

In his research, Sadler (1989) talked about closing the gap between what students knew and what students still needed to know. Students used similar language when talking about their perceptions about formative assessment. The themes that emerged about knowing their wrong answers, being informed about their learning, getting a deeper understanding, and prepping for assessments were all associated with the idea of bridging the gap between what students knew and what they needed to know. For students, it was more than just knowing where they made mistakes, but understanding why they made mistakes and how they needed to improve.

## **Formative Assessment in Science**

Although this study took place in chemistry classes, the findings lack a direction connection between the formative assessment strategies and the science content. Throughout the “truth box” vignettes and the interviews students talked about their learning and understanding in a general sense, but did not talk about specific objectives related to chemistry they mastered. In a few instances students did use science vocabulary. Students appeared to think of the benefits of the strategies of formative assessment in terms of their learning and experiences in the classroom, outside of any content connection. This suggests that these findings have a broader application across disciplines and may be applied outside the realm of science.

### **Implications**

This study provided insight into the ways students viewed formative assessment as a part of their educational experience, which has implications for teachers, especially in science. It appeared that the major strategies of formative assessment encouraged and fostered a growth mindset where students felt like advocates of their learning. Students used formative assessment and acknowledged many benefits, both for their learning and for their interpersonal feelings. Information about what they were expected to know and learn became clear. They felt empowered with the confidence to try again because they were in an environment where making mistakes was seen as a part of the learning process as another step in improvement and learning. Students appreciated the individualization of the feedback, self-assessment, and questioning provided.

Students engaged in class because formative assessment made them feel good about the learning process, made the learning experience personalized, clarified the

expectations, and in many instances allowed them to socialize and interact with both peers and the instructor. For teachers, this insight into the ways students perceived formative assessment offers a better understanding of students and what they need to thrive and learn in the science classroom. By understanding what students perceive as their needs, teachers can engage more students in the learning process.

Of special note is that while this study focused on the implementation of four strategies outlined for the literature, these four strategies were not implemented for the first time during the time of the study. Rather in the years leading up to the data collection, most of the strategies had been implemented in an informal or formal way. Only questioning had not been explicitly implemented. If teachers are looking to integrate formative assessment into their classrooms, the recommendation is to start gradual with one strategy and focus on implementing that strategy well. As the teacher and students become comfortable with that strategy, enhance the strategy or integrate another strategy. For example, after becoming comfortable with whole class feedback, a teacher might then work on providing individual written feedback. Or if a teacher notices that students are becoming more accustomed to self-assessing with clear criteria, then move onto questioning activities that aim to elicit evidence of learning. In the beginning certain strategies, like feedback might take more time, but by frontloading the work with a rough draft of a laboratory report or quiz, the final version will actually take less time to grade because either the student does not make changes and there is no change to the grade or, the desired result, a better, more polished version demonstrating student learning. To prevent feeling overwhelmed or burnt out these strategies need to be implemented steadily over time as the teacher and students appear ready. Quantity of

strategies implemented should not happen at the expense of the quality of strategies implemented.

### **Suggestions for Future Research**

This study focused on the implementation of four of the major strategies associated with formative assessment and the perceptions of high school science students about their learning in science class. While the perceptions of these students provided insight into how students viewed and ultimately used feedback, questioning, self-assessment, and summative tests formatively, the generalizability of the findings is limited due to the small number of students. This particular study did not look at the relationship between students' perceptions of their learning experiences with formative assessment and their achievement. Future studies might look how students' ideas about their learning correlate with their final grade in the class or scores on standardized tests.

Future research would also need to look at more students across multiple schools and districts. The study might also randomly assign some students to science teachers who are actively implementing formative assessment, and other students to science teachers who are not. Over time, study might look at students' perceptions about their learning, attitudes and motivation and see if there is any difference between the two groups of students.

Due to time constraints this study did not look at the ways students perceived peer assessment. Many studies have already been done that look at the implementation and practice of peer-assessment, and touch on student views of said peer assessment (Scruggs & Mastropieri, 1998; Topping, 1998; Topping, 2003). Future studies would include this other major strategy of formative assessment, especially in the ways it can be done

effectively in science as most studies have been done in the humanities (O'Donnell & Topping, 1998; Weaver, 1995).

## References

- Atwater, M. M. (2000). Equity for Black Americans in precollege science. *Science Education, 84*(2), 154-179.
- Andrade, H. L. (2010). Students as the definitive source of formative assessment: Academic self-assessment and the self-regulation of learning. In H. L. Andrade & G. J. Cizek (Eds.), *Handbook of formative assessment* (pp. 90-105) New York, NY: Routledge.
- Andrade, H. L. & Cizek, G. J. (2010). *Handbook of formative assessment*. New York, NY: Routledge.
- Andrade, H. L. & Du, Y. (2007). Student responses to criteria-reference self-assessment. *Assessment & Evaluation in Higher Education, 32*(2), 159-181.
- Bell, B. & Cowie, B. (2001). The characteristics of formative assessment in science education. *Science Education, 85*, 536-553.
- Black, P., & Harrison, C. (2001a). Feedback in questioning and marking: The science teacher's role in formative assessment. *School Science Review, 82*(301), 55-61.
- Black, P., & Harrison, C. (2001b). Self- and peer-assessment and taking responsibility: The science student's role in formative assessment. *School Science Review, 83*(302), 43-49.
- Black, P., Harrison, C., Lee, C., Marshall, B., & Wiliam, D. (2003). *Assessment for learning: Putting it into practice*. New York, NY: Open University Press.
- Black, P., Harrison, C., Lee, C., Marshall, B., & Wiliam, D. (2004). Working inside the black box: Assessment for learning in the classroom. *Phi Delta Kappan, 86*(1), 9-21.

- Black, P., & Wiliam, D. (1998a). Assessment and classroom learning. *Assessment in Education: Principles, Policy & Practice*, 5(1), 7-74.
- Black, P. & Wiliam, D. (1998b). Inside the black box: Raising standards through classroom assessment. *Phi Delta Kappan*, 80(2), 139-148.
- Black, P. & Wiliam, D. (2009). Developing the theory of formative assessment. *Educational Assessment, Evaluation, and Accountability*, 21(1), 5-31.
- Brookhart, S. M. (2001). Successful students' formative and summative uses of assessment information. *Assessment in Education: Principles, Policy & Practice*, 8(2), 153-169.
- Brookhart, S. M. (2003). Developing measurement theory for classroom assessment purposes and uses. *Educational Measurement: Issues and Practice*, 22(4), 5-12.
- Butler, R. (1988) Enhancing and undermining intrinsic motivation; the effects of task-involving and ego-involving evaluation on interest and performance. *British Journal of Educational Psychology*, 58, 1-14.
- Carlson, M. O., Humphrey, G. E., & Reinhardt, K.S. (2003). *Weaving science inquiry and continuous assessment: Using formative assessment to improve learning*. Thousand Oaks, CA: Corwin Press, Inc.
- Casteel, C. (1997). Attitudes of African American and Caucasian eighth grade students about praises, rewards, and punishments. *Elementary School Guidance and Counseling*, 31, 262-272.
- Centre for Educational Research and Innovation. (2005). *Formative Assessment: Improving learning in secondary classrooms*. France: Organization for Economic Co-operation and Development.

- Coffey, J. E., Hammer, D., Levin, D. M., & Grant, T. (2011). The missing disciplinary substance of formative assessment. *Journal of Research in Science Teaching*, 48(10), 1109-1136.
- Cowie, B. (2005a). Student commentary on classroom assessment in science: a sociocultural interpretation. *International Journal of Science Education*, 27(2), 199-214.
- Cowie, B. (2005b). Pupil commentary on assessment for learning. *Curriculum Journal*, 16(2), 137-151.
- Dweck, C. S. (2000). *Self-theories: Their role in motivation, personality, and development*. New York; Psychology Press.
- Emdin, C. (2011). Dimensions of communication in urban science education: Interactions and transactions. *Science Education*, 95(1), 1-20.
- Furtak, E. M., & Ruiz-Primo, M. A. (2008). Making Students' Thinking Explicit in Writing and Discussion: An Analysis of Formative Assessment Prompts. *Science Education*, 92(5), 799-824.
- Gioka, O. (2009). Teacher or examiner? The tensions between formative and summative Assessment in the Case of Science Coursework. *Research in Science Education*, 39(4), 411-428.
- Guskey, T. R. (1997). *Implementing mastery learning*. 2<sup>nd</sup> Edition. Belmont, CA: Wadsworth Publishing.
- Guskey, T. R. (2008). The rest of the story. *Educational Leadership*, 65(4), 28-35.
- Guskey, T. R. (2010). Formative assessment: The contributions of Benjamin S. Bloom. In

- H. L. Andrade & G. J. Cizek (Eds.), *Handbook of formative assessment* (pp. 106-124) New York, NY: Routledge.
- Hanrahan, S. J. & Isaac, G. (2001). Assessing self- and peer-assessment: The students' views. *Higher Education Research & Development*, 20(1), 53-70.
- Harlen, W. (2005). Teachers' summative practices and assessment for learning – tensions and synergies. *Curriculum Journal*, 16(2), 207-223.
- Hattie, J. & Timperley, H. (2007). The power of feedback. *Review of Educational Research*, 77(1), 81-112.
- Hounsell, D. (1997) Contrasting conceptions of essay-writing. In F. Marton, D. Hounsell & N. Entwistle (Eds.), *The experience of learning*. 2<sup>nd</sup> Edition. Edinburgh, Scotland: Scottish Academic Press.
- Hughes, G. (2011). Aiming for personal best: A case for introducing ipsative assessment in higher education. *Studies in Higher Education*, 36(3), 353 – 367.
- Kyle, W. C., Bonnstetter, R. J., & McCloskey, S. (1985). What research says: Science through discovery: students love it. *Science and Children*, 23, 39–41.
- Ladson-Billings, G. (1994). *The dreamkeepers: successful teachers of African American children*. San Francisco, CA: Jossey-Bass.
- Leahy, S., Lyon, C., Thompson, M., & Wiliam, D. (2005). Classroom Assessment: Minute by Minute, Day by Day. *Educational Leadership*, 63(3), 18-24.
- Lee, P. (1999). In their own voices: An ethnographic study of low-achieving students within the context of school reform. *Urban Education*, 34(2), 214-244.
- McMillan, J. H. (2007). Formative classroom assessment: The key to improving student

- achievement. In J. H. McMillan, (Ed.) *Formative classroom assessment: theory into practice* (1-7). New York: Teachers College Press.
- McTighe, J., & O'Connor, K. (2005). Seven Practices for Effective Learning. (Cover story). *Educational Leadership*, 63(3), 10-17.
- Miles, M. B. & Huberman, A. M. (1994). *Qualitative data analysis*. 2<sup>nd</sup> Edition. Thousand Oaks, CA: Sage Publications, Inc.
- Minnesota Department of Education. (2011). *2010-2011 Enrollment by gender/ethnicity*. Retrieved from Minnesota Department of Education website:  
<http://education.state.mn.us/MDEAnalytics/Data.jsp>
- National Research Council. (1996). *National science education standards*. Washington, DC: National Academy Press.
- National Research Council. (2001a). *Classroom Assessment and the National Science Education Standards*. Washington, DC: The National Academies Press.
- National Research Council. (2001b). *Knowing What Students Know: The Science and Design of Educational Assessment*. Washington, DC: The National Academies Press.
- National Research Council. (2012). *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*. Washington, DC: The National Academies Press.
- Nicol, D. J. & Macfarlane-Dick, D. (2006). Formative assessment and self-regulated learning: A model and seven principles of good feedback practice. *Studies in Higher Education*, 31(2), 199-218.
- O'Donnell, A. M. & Topping, K. J. (1998). Peers assessing peers: Possibilities and

- problems. In K. J. Topping & S. Ehly (Eds.), *Peer-assisted learning* (pp. 255-278). Mahwah, NJ: Erlbaum.
- Patton, M. Q. (2002). *Qualitative research and evaluation methods*. Thousand Oaks, CA: Sage Publications, Inc.
- Prime, G. M. & Miranda, R. J. (2006). Urban public high school teachers' beliefs about science learner characteristics: Implications for curriculum. *Urban Education, 41*(5), 506-532.
- Rakow, S. J. (1986). *Teaching science as inquiry*. Bloomington, IN: Phi Delta Kappa Educational Foundation.
- Ramaprasad, A. (1983). On the definition of feedback, *Behavioral Science, 28*(1), 4-13.
- Rowe, M. B. (1974). Wait-time and rewards as instructional variables, their influence on language, logic, and fate control: Part one-wait-time. *Journal of Research in Science Teaching, 11*(2), 81-94.
- Rubin, H. J. & Rubin, I. S. (2005). *Qualitative interviewing: The art of hearing data*. 2<sup>nd</sup> Edition. Thousand Oaks, CA: Sage Publications, Inc.
- Ruiz-Primo, M. A. & Furtak, E. M. (2007). Exploring teachers' informal assessment practices and students' understanding in the context of scientific inquiry. *Journal of Research in Science Teaching, 44*(1), 57-84.
- Sadler, D. R. (1989). Formative assessment and the design of instructional systems. *Instructional Science, 18*(2), 119-44.
- Sadler, P. & Good, E. (2006). The impact of self- and peer-grading on student learning. *Educational Assessment, 11*(1), 1-31.
- Sato, M., Coffey, J., & Moorthy, S. (2005). Two teachers making assessment for learning

- their own. *Curriculum Journal*, 16(2), 177-191.
- Scruggs, T. E. & Mastropieri, M. A. (1998). Tutoring and students with special needs. In K. J. Topping & S. Ehly (Eds.), *Peer-assisted learning* (pp. 165-182). Mahwah, NJ: Erlbaum.
- Shavelson, R. J., Yin, Y., Furtak, F. M., Ruiz-Primo, M. A., Ayala, C. C., Young, D. B., Tomita, M. K., Brandon, P. R., & Pottenger III, F. M. (2008a). On the role and impact of formative assessment on science inquiry teaching and learning. In J. Coffey, R. Douglas, & C. Stearns (Eds.), *Assessing science learning: Perspectives from research and practice* (pp. 21-36) Arlington, VA: NSTA Press.
- Shepard, L.A. (2008). Formative assessment: Caveat emptor. In C.A. Dwyer (Ed.), *The future of assessment: Shaping teaching and learning* (pp. 279-304). New York: Lawrence Erlbaum Associates.
- Shymansky, J. A., Hedges, L. V., & Woodworth, G. (1990). A reassessment of the effects of inquiry-based science curricula of the 60's on student performance. *Journal of Research in Science Teaching*, 27, 127-144.
- Stiggins, R. J. (1999). Assessment, student confidence, and school success. *Phi Delta Kappan*, 81 (3), 191-198.
- Stiggins, R. J. (2007). Conquering the formative assessment frontier. In J. H. McMillan, (Ed.) *Formative classroom assessment: theory into practice* (8-28). New York: Teachers College Press.
- Stiggins, R. (2009). Assessment "for" Learning in Upper Elementary Grades. *Phi Delta Kappan*, 90(6), 419-421.
- Stiggins, R., Arter, J., Chappuis, J., & Chappuis, S. (2004). *Classroom assessment for*

- student learning : doing it right -- using it well*. Upper Saddle River, NJ: Pearson Education, Inc.
- Stiggins, R. & Chappuis, J. (2006). What a difference a word makes. *Journal of Staff Development*, 27(1), 10-14.
- Strauss, A. L. & Corbin, J. (1990). *Basics of qualitative research: Grounded theory procedures and techniques*. Newbury Park, CA: Sage Publications, Inc.
- Topping, K. J. (1998). Peer assessment between students in college and university. *Review of Educational Research*, 68, 249-276.
- Topping, K. J. (2003). Self and peer assessment in school and university: Reliability, validity, and utility. In M. Segers, F. Dochy, & E. Cascallar (Eds.), *Optimizing new modes of assessment: In search of qualities and standards* (pp. 55-87), Boston, MA: Kluwer Academic Publishers.
- Treagust, D. F., Jacobowitz, R., Gallagher, J. L., & Parker, J. (2001). Using assessment as a guide in teaching for understanding: A case study of a middle school science class learning about sound. *Science Education*, 85, 137-157.
- U.S. Census Bureau. (2012). *Statistical Abstract of the United States: 2012*. Retrieved from United States Census Bureau website:  
<http://www.census.gov/prod/2011pubs/12statab/pop.pdf>
- Weaver, M. E. (1995). Using peer response in the classroom: Students' perspectives. *Research and Teaching in Developmental Education*, 12, 31-37.
- Wenzel, T. J. (2007). Evaluation tools to guide students' peer-assessment and self-assessment in group activities for the lab and classroom. *Journal of Chemical Education*, 84(1), 182-186.

- Wiliam, D. (2008). Improving learning in science with formative assessment. In J. Coffey, R. Douglas, & C. Stearns (Eds.), *Assessing science learning: Perspectives from research and practice* (pp. 3-20) Arlington, VA: NSTA Press.
- Wiliam, D. & Leahy, S. (2007). A theoretical foundation for formative assessment. In J. H. McMillan, (Ed.) *Formative classroom assessment: Theory into practice* (29-42). New York: Teachers College Press.
- Wiliam, D., Lee, C., Harrison, C., & Black, P. (2004). Teachers developing assessment for learning: impact on student achievement. *Assessment in Education: Principles, Policy & Practice*, 11(1), 49-65.
- Wiliam, D. & Thompson, M. (2008). Integrating assessment with instruction: What will it take to make it work? In C. A. Dwyer (Ed.) *The future of assessment: Sharpening teaching and learning* (pp. 53-92). Mahwah, NJ: Erlbaum.
- Yin, Y., Shavelson, R. J., Ayala, C. C., Ruiz-Primo, M. A., Brandon, P. R., Furtak, E. M., Tomita, M. K., & Young, D. B. (2008). On the impact of formative assessment on student motivation, achievement, and conceptual change. *Applied Measurement in Education*, 21, 335-359.

## Appendix A

### Learning Targets Handout

#### Learning Targets – The Periodic Table

Name: \_\_\_\_\_ Date: \_\_\_\_\_ Period: 1 2 3 4 5 6

**Unit EU:** The natural world is full of patterns made evident by observation.

**Unit EQ:** How do you use patterns?

**Unit Area of Interaction:** Human Ingenuity - The modern periodic table is standing on the shoulders of giants—a compilation of discoveries made by many people over time.

#### Assessment Scale

5 – “Get it.” I fully understand and know everything. I can teach this concept to another student. Mastered the concept. (Deeper understanding)

4 – “Get it, but can’t teach it.” I know most of the information and feel comfortable/confident. (Deeper understanding)

3 – “Starting to get it.” I know some things and starting to understand. Still need teacher help. (Basic understanding)

2 – “Don’t get most of it.” I know and understand a little bit, but I am still confused. (Basic understanding)

1 – “Eh???” I don’t know or understand anything. Need lots of help. I feel frustrated and lost. (No understanding)

#### Self-Assessment – The Periodic Table

Learning Targets	1	2	3	4	5
1. I can describe Dalton’s atomic theory.					
2. I can relate my investigations with puzzles to Mendeleev's struggle to determine the Periodic Law.					
3. I can describe the different families of the periodic table and their chemical/physical properties (alkali metals alkaline earth metals, transition metals, halogens, noble gases, lanthanides/actinides, etc).					
4. I can calculate density using the (mass/volume) equation.					
5. I can predict the properties of elements using the Periodic Law (density, solubility, and reactivity).					
6. I can apply the Periodic Law to explain patterns in the periodic table.					
7. I can connect the concept of relative mass to the Bean Lab.					

8. I can determine the number of atoms by measuring the mass of any element - Avogadro's # = $(6.02 \times 10^{23}$ things = 1 mole).					
9. I can investigate properties of elements.					
10. I can identify the names and symbols of 30 of the most common elements.					

## Appendix B

### Post Lab Questions

#### Properties of Elements in Our Environment

Name: \_\_\_\_\_

Period: 1 2 3 4 5 6

Lab Group: 1 2 3 4 5 6 7 8 9 10 11 12

*Post Lab Questions – Answer after the lab.*

1. What are the properties of metals (that you knew before and from what you learned in this lab)?
2. What are the properties of nonmetals (that you knew before and from what you learned in this lab)?
3. Are there any “crossover elements,” that is, do any of the elements appear to have properties of both metals and nonmetals? Explain your thoughts and name any possible borderline elements.
4. Based on general knowledge of metals and the answer to Questions #1, 2, and 3, classify each element tested as a metal, nonmetal, or metalloid.

aluminum \_\_\_\_\_ sulfur \_\_\_\_\_

carbon \_\_\_\_\_ tin \_\_\_\_\_

iron \_\_\_\_\_ zinc \_\_\_\_\_

magnesium \_\_\_\_\_ silicon \_\_\_\_\_

5. Classify the following elements as metal, nonmetal, or metalloid –

selenium \_\_\_\_\_ calcium \_\_\_\_\_

cobalt \_\_\_\_\_ arsenic \_\_\_\_\_

phosphorus \_\_\_\_\_ barium \_\_\_\_\_

6. After completing this lab, how do you feel about physical and chemical properties? If you are a 4 or 5, explain the difference between these types of properties. If you are a 1, 2, or 3 write down how the instructor or a “5” student can help you.

## Appendix C

### Test

**The Periodic Table TEST**  
**Learning Targets #2, 3, 5, 6, 7, 8**

**Name:** \_\_\_\_\_  
**Period:** 1 2 3 4 5 6

**On the last page is a Periodic Table to use as a reference,**  
**BUT you can use your own too! ☺**

**Learning Target #2** – I can discover repeating patterns and use them to make predictions.

**Learning Target #3** - I can relate the “puzzle pattern activity” to Dmitri Mendeleev’s struggle to discover the Periodic Law.

***Directions: Answer the following questions in COMPLETE SENTENCES.***

1. Why was Mendeleev’s table of elements so amazing?

---

---

---

2. How was your experience with the puzzle activity (the puzzle with the different colored pieces with numbers, holes and stars) similar to Mendeleev’s experience with the elements?

---

---

---

3. Why would the “Pattern Table” be another good name for the periodic table of elements?

---

---

---

**Learning Target #5** - I can describe and apply Mendeleev's Periodic Law to explain patterns in the periodic table.

**Directions:** Answer the following questions.

1. How does the periodic law help us to understand the elements?

---

---

---

2. In your own words, describe the way the periodic table is organized.

---

---

---

3. Explain 2 reasons why hydrogen is unique among all the elements.

---

---

---

---

**Learning Target #6** - I can describe the different families of the periodic table and their chemical/physical properties (*alkali metals, alkaline earth metals, transition metals, halogens, noble gases, lanthanides/actinides*).

**Directions:** Match the family with the description. Some families will be used more than once.

alkali metals

nobles gases

actinides/lanthanides

alkaline earth metals

halogens

transition metals

7. Fluorine (F), bromine (Br), or iodine (I)

---

8. Elements that are the most reactive in water

---

9. Sodium (Na) or cesium (Cs)

---

10. Most reactive of all the elements

---

11. Magnesium (Mg) or barium (Ba)

---

12. Used in making planes and cars

---

13. Most of the elements are radioactive

---

14. Many of the elements are used to make jewelry

---

15. Found in the earth

---

16. All are gases at room temperature

---

17. Which element is all alone without a family?

---



**Learning Target #8** - I can predict the properties of elements using the Periodic Law (density, solubility, and reactivity).

**Directions:** Answer the following questions.

1. *True or False (circle one).* The alkaline earth metals tend to be basic.
2. What is the trend in reactivity of metals as you move across a horizontal row?
3. Based on the solubility trend as you move down a vertical column, which element is less soluble (forms more precipitates), calcium (Ca) or barium (Ba)?
4. Based on the reactivity trend as you move down a vertical column, which element should react more when placed in water, sodium (Na) or rubidium (Rb)?
5. If density increases as you move down the periodic table. Which element would have the higher density; nickel (Ni) or platinum (Pt)?

**The Periodic Table of the Elements**

1 <b>H</b> Hydrogen 1.00794																	2 <b>He</b> Helium 4.003
3 <b>Li</b> Lithium 6.941	4 <b>Be</b> Beryllium 9.012182											5 <b>B</b> Boron 10.811	6 <b>C</b> Carbon 12.0107	7 <b>N</b> Nitrogen 14.00674	8 <b>O</b> Oxygen 15.9994	9 <b>F</b> Fluorine 18.9984032	10 <b>Ne</b> Neon 20.1797
11 <b>Na</b> Sodium 22.989770	12 <b>Mg</b> Magnesium 24.3050											13 <b>Al</b> Aluminum 26.981538	14 <b>Si</b> Silicon 28.0855	15 <b>P</b> Phosphorus 30.973761	16 <b>S</b> Sulfur 32.066	17 <b>Cl</b> Chlorine 35.4527	18 <b>Ar</b> Argon 39.948
19 <b>K</b> Potassium 39.0983	20 <b>Ca</b> Calcium 40.078	21 <b>Sc</b> Scandium 44.955910	22 <b>Ti</b> Titanium 47.867	23 <b>V</b> Vanadium 50.9415	24 <b>Cr</b> Chromium 51.9961	25 <b>Mn</b> Manganese 54.938049	26 <b>Fe</b> Iron 55.845	27 <b>Co</b> Cobalt 58.933200	28 <b>Ni</b> Nickel 58.6934	29 <b>Cu</b> Copper 63.546	30 <b>Zn</b> Zinc 65.39	31 <b>Ga</b> Gallium 69.723	32 <b>Ge</b> Germanium 72.61	33 <b>As</b> Arsenic 74.92160	34 <b>Se</b> Selenium 78.96	35 <b>Br</b> Bromine 79.904	36 <b>Kr</b> Krypton 83.80
37 <b>Rb</b> Rubidium 85.4678	38 <b>Sr</b> Strontium 87.62	39 <b>Y</b> Yttrium 88.90585	40 <b>Zr</b> Zirconium 91.224	41 <b>Nb</b> Niobium 92.90638	42 <b>Mo</b> Molybdenum 95.94	43 <b>Tc</b> Technetium (98)	44 <b>Ru</b> Ruthenium 101.07	45 <b>Rh</b> Rhodium 102.90550	46 <b>Pd</b> Palladium 106.42	47 <b>Ag</b> Silver 107.8682	48 <b>Cd</b> Cadmium 112.411	49 <b>In</b> Indium 114.818	50 <b>Sn</b> Tin 118.710	51 <b>Sb</b> Antimony 121.760	52 <b>Te</b> Tellurium 127.60	53 <b>I</b> Iodine 126.90447	54 <b>Xe</b> Xenon 131.29
55 <b>Cs</b> Cesium 132.90545	56 <b>Ba</b> Barium 137.327	57 <b>La</b> Lanthanum 138.9055	72 <b>Hf</b> Hafnium 178.49	73 <b>Ta</b> Tantalum 180.9479	74 <b>W</b> Tungsten 183.84	75 <b>Re</b> Rhenium 186.207	76 <b>Os</b> Osmium 190.23	77 <b>Ir</b> Iridium 192.217	78 <b>Pt</b> Platinum 195.078	79 <b>Au</b> Gold 196.96655	80 <b>Hg</b> Mercury 200.59	81 <b>Tl</b> Thallium 204.3833	82 <b>Pb</b> Lead 207.2	83 <b>Bi</b> Bismuth 208.98038	84 <b>Po</b> Polonium (209)	85 <b>At</b> Astatine (210)	86 <b>Rn</b> Radon (222)
87 <b>Fr</b> Francium (223)	88 <b>Ra</b> Radium (226)	89 <b>Ac</b> Actinium (227)	104 <b>Rf</b> Rutherfordium (261)	105 <b>Db</b> Dubnium (262)	106 <b>Sg</b> Seaborgium (263)	107 <b>Bh</b> Bohrium (262)	108 <b>Hs</b> Hassium (265)	109 <b>Mt</b> Meitnerium (266)	(269)	(272)	(277)						
58 <b>Ce</b> Cerium 140.116	59 <b>Pr</b> Praseodymium 140.90765	60 <b>Nd</b> Neodymium 144.24	61 <b>Pm</b> Promethium (145)	62 <b>Sm</b> Samarium 150.36	63 <b>Eu</b> Europium 151.964	64 <b>Gd</b> Gadolinium 157.25	65 <b>Tb</b> Terbium 158.92534	66 <b>Dy</b> Dysprosium 162.50	67 <b>Ho</b> Holmium 164.93032	68 <b>Er</b> Erbium 167.26	69 <b>Tm</b> Thulium 168.93421	70 <b>Yb</b> Ytterbium 173.04	71 <b>Lu</b> Lutetium 174.967				
90 <b>Th</b> Thorium 232.0381	91 <b>Pa</b> Protactinium 231.03588	92 <b>U</b> Uranium 238.0289	93 <b>Np</b> Neptunium (237)	94 <b>Pu</b> Plutonium (244)	95 <b>Am</b> Americium (243)	96 <b>Cm</b> Curium (247)	97 <b>Bk</b> Berkelium (247)	98 <b>Cf</b> Californium (251)	99 <b>Es</b> Einsteinium (252)	100 <b>Fm</b> Fermium (257)	101 <b>Md</b> Mendelevium (258)	102 <b>No</b> Nobelium (259)	103 <b>Lr</b> Lawrencium (262)				









**Learning Target #6 - I can apply the Periodic Law to explain patterns in the periodic table.**

*Directions: Answer the following questions.*

**WRITE IN COMPLETE SENTENCES!!!**

1. What characteristics did Mendeleev use to organize the elements?

---

---

---

2. In your own words, describe the way the periodic table is organized.

---

---

---

3. What did the gaps on Mendeleev's periodic table represent?

---

---

---

**Learning Target #6 - I can describe the different families of the periodic table and their chemical/physical properties (alkali metals, alkaline earth metals, transition metals, halogens, noble gases, lanthanides/actinides).**

*Directions: Match the family from the periodic table with the description. Some of the families will be used more than once.*

alkali metals                  nobles gases                  actinides/lanthanides                  hydrogen

alkaline earth metals                  halogens                  transition metals

- 18. Xenon (Xe) or neon (Ne) \_\_\_\_\_
- 19. Most reactive elements \_\_\_\_\_
- 20. Radioactive family \_\_\_\_\_
- 21. Lithium (Li) or rubidium (Rb) \_\_\_\_\_
- 22. Metals commonly used everyday \_\_\_\_\_
- 23. Very reactive elements in water \_\_\_\_\_
- 24. Elements found in processes of the body \_\_\_\_\_
- 25. Many of the elements are used to make jewelry \_\_\_\_\_
- 26. Has only one proton and one electron \_\_\_\_\_
- 27. These elements do not bond with other elements \_\_\_\_\_



***Learning Target #8 - I can predict the properties of elements using the Periodic Law (density, solubility, and reactivity).***

*Directions: Answer the following questions.*

6. *True or False.* The alkaline earth metals tend to be acidic.
7. What is the trend of solubility as you move down a vertical column?
  
8. What is the trend in reactivity of metals as you move down a vertical column?
  
9. Based on the solubility trend as you move down a vertical column, which element should form more precipitates (cloudy solutions), magnesium (Mg) or calcium (Ca)?
  
10. Based on the reactivity trend as you move down a vertical column, which element should react more when placed in water, lithium (Li) or cesium (Cs)?

## **Appendix F**

### **“Truth Box” Protocol**

1. Tell me what you know about...(cite specific unit or topic or objective).
2. Tell me what you think about...(cite specific formative assessment strategy).
3. Did this strategy help you learn?
  - a. If yes, how did this strategy help you learn?
  - b. If no, why do you think it did not help you learn?

## Appendix G

### Interview Protocol

- Describe a situation where you felt confident about your learning.
- How do you know you understand an activity or concept? How do you know you learned the concept?
- What do you do when you struggle with an activity or concept?
- Tell me what you think about using:
  - activities where I ask lots of questions?
  - post lab questions and discussions?
  - formative assessment probes?
  
  - written feedback on quizzes?
  - written feedback on papers?
  - oral feedback and review (i.e. post quiz)?
  - one-on-one interaction and feedback with instructor?
  
  - learning targets?
  - self-assessment activities?
  
  - option to retake quizzes?
  - corrections?
- Did this activity help you learn? (In reference to each of the above activities).
  - If yes → How did this activity help you learn?
  - If no → Why do you think this activity did not help you learn? What activity did help you learn?
- What final thoughts do you have about your learning in chemistry over the past trimester?