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Formative assessment: the effect on academic achievement and attitudes toward science

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FORMATIVE ASSESSMENT:

THE EFFECT ON ACADEMIC ACHIEVEMENT AND ATTITUDES TOWARD SCIENCE

by
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ABSTRACT

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The purposes of this study were to (a) determine if the use of formative assessment in the science classroom improved academic achievement in a group of ninth grade honors level students; and (b) determine the effect of formative assessment on the attitudes these students have toward science. Data was collected from two control groups (N=24 and N=26) and the experimental comparison group (N=28). Students were administered two Likert-type surveys, an attitude survey and a causal attribution survey. Each survey was given at the start of the experiment and again at the end of the experiment. Summative test scores were also collected over the course of the investigation. The mean and standard deviation for summative test scores were compared. Analysis of the attitude surveys was done using an independent-sample t-test and a Bonferroni One-way Analysis of Variance (ANOVA). While the analysis of summative test scores did not show an overall increase in scores, there was a narrowing of the gap between high and low achievers which may demonstrate a relationship between achievement and formative assessment. Most results of the attitude and causal attribution surveys were not

statistically significant. The attitude survey showed a possible relationship between the use of formative assessment and improved attitudes toward the usefulness of science. Results of the causal attribution survey showed a possible relationship between the use of formative assessment and the attribution of success in science to ability and effort. These attributions are associated with facilitated learning experiences.

TABLE OF CONTENTS

6. LIST OF TABLES

Chapter 1

INTRODUCTION

Statement of the Problem

Formative assessment is a practice in which constructive feedback is frequently given to students. Feedback may come from the teacher, other students, or self-reflections. In order for an assessment to be formative, it must be useful in improving the teaching and learning process. Currently, most educational systems emphasize summative assessment. This type of assessment evaluates learning at a particular point in time, perhaps the end of a unit of study or the end of a semester. Summative assessments offer minimal opportunity for improvement in teaching and learning. An extensive literature review summarized by Paul Black and Dylan Wiliam's "Inside the Black Box: Raising Standards through Classroom Assessment" (*Phi Delta Kappan*, October, 1998) discusses evidence that formative assessment raises achievement overall. Summative tests place an emphasis on competition and numeric grades as opposed to advice and learning.

As the quantity of scientific knowledge increases, it is apparent that science students need to shift their focus from passing a test to learning to understand. It is virtually impossible to remember the amount of factual knowledge available, but necessary to learn to understand major concepts so that they may be applied to real-life situations. According to Sadler (1989) students must take action to close the gap between what they know and what is expected. Teachers can aid students in this process by providing opportunities for formative assessment.

Purpose of the Study

The purposes of this study were to determine if the use of formative assessment in the science classroom improved academic achievement in a group of ninth grade honors level students (N=28); and to determine the effect of formative assessment on the attitudes these students have toward science.

Research Questions

In order to determine if a relationship exists between the use of formative assessment and improved academic achievement and attitudes toward science, the following questions were developed:

1. Will the use of formative assessment in the science classroom enhance academic achievement as shown through an increase overall in summative assessment scores?
2. Will the use of formative assessment in the science classroom improve achievement as shown through narrowing the gap between high and low achievers?
3. Will the use of formative assessment improve attitudes toward science as shown through statistical analysis of attitude and causal attribution surveys?

These questions guided the development of a quantitative study employing Likert-type attitude and attribution instrument scales as well as analysis of summative test scores. Because the sample was not randomly selected, results from this study cannot be generalized to the population. Descriptive statistics were used in order to summarize typical characteristics of this particular group.

Operational Definitions

The following definitions are given to provide a context for the reader.

1. Achievement

Ability to demonstrate accomplishment in learning. This study compared summative assessment scores of the control to the comparison group in order to determine whether an increase in achievement existed.

2. Formative Assessment

Any activity employed by the teacher or the student to improve the teaching and the learning. The strategies of formative assessment in this study included comment-only marking, increased wait time, discussion based on common experiences, and self-assessment.

3. Attitude

Predisposition to respond favorably or unfavorably to an object, group, or place. Generally predicts behavior, likes and dislikes (McMillan, 2000).

Hypothesis

It is hypothesized that the incorporation of formative assessment into the physical science classroom will improve academic achievement and attitudes toward science.

Chapter 2

REVIEW OF LITERATURE

Formative Assessment

Assessments are used in schools for a variety of reasons. These assessments may be formative or summative in nature. Summative assessments are often employed at the end of a semester or a unit of study. These assessments are used to indicate a ranking of students within a class or to reflect a level of understanding that students may have of the material. Results of summative assessments are also used by teachers in planning future course organization. Dixon and Ecclestone (2003) stated that the purpose of summative assessment was to promote and accredit competence. According to the National Research Council (1996), state and national summative assessments are given for the following reasons:

1. Ranking of public elementary and secondary schools
2. Decision making about state and federal monetary allocations
3. Continuing academic certification
4. Determining teachers' salaries

The data from these standardized summative tests can, however, be used in a formative manner. Results of these tests, for example, may allow students needing special instructional programs to be identified. Also, the tests can serve as a means of accountability for taxpayers regarding the use of public funds.

Summative assessment practices do not focus on learning, but rather the assignment of a final grade, leaving no room for improvement. This has led to a competitive environment with emphasis being placed more heavily on reliability than validity of assessment (Dixon & Ecclestone, 2003). Summative testing emphasizes the teacher's managerial role of numbers being placed on student records rather than the teacher's role as a guide to learning. This leads students to focus more on competition as opposed to mastery. When the focus in the classroom is a grade, students invest more interest in finding ways to obtain the best marks and less interest in improving their learning (Black & Wiliam, 1998). While summative assessments are useful for some purposes, they offer minimal opportunity for students to improve their learning. Low-achieving students come to believe that they are not able to learn. They attribute their failure to a lack of ability (Vispoel & Austin, 1995).

Assessments become formative when the information received is used to adjust the instruction to improve learning. Following an extensive review of research, Black and Wiliam (1998b) defined formative assessment as

> All those activities undertaken by teachers and/or by their students which provide information to be used as feedback to modify the teaching and learning activities in which they are engaged.

Feedback should focus on informing students of what they can do to improve. It should not encourage students to compare themselves.

Support of Formative Assessment

The King's-Medway-Oxfordshire Formative Assessment Project, funded by the Nuffield Foundation and the National Science Foundation, provided evidence that formative assessment positively impacts external assessments (Wiliam, Lee, Harrison, & Black, 2004). This study offered support and guidance to twenty-four math and science teachers in incorporating formative assessment into their classrooms. Performance of the formative assessment groups was compared with performance of parallel groups of students who received traditional summative assessments only. Teachers involved in the study were introduced to the principles of formative assessment, but encouraged to develop their own plan given the complexity of individual classroom environments. Teachers were supported with in-services, observations, and discussions with the project staff. Conclusions about student learning were based on comparisons of school-administered assessments that were given over the course of the year as well as national tests. While the researchers acknowledged that quantitative data in this type of study was difficult to interpret, the investigation did provide evidence that formative assessment produced improved outcomes as shown in externally administered assessments (Wiliam, *et.al.*, 2004).

In recent years the amount of factual information available for students to learn has exponentially increased. This is especially true in the field of science. Because of this there needs to be a greater emphasis on the type of learning that will enable students to apply knowledge to new circumstances rather than learning facts that are applicable only to situations specifically learned. It has become important that students learn not for the purpose of achieving a high score on a test, but that they learn for understanding (Harlen, 1997). As noted by Crooks (1988), detailed factual knowledge decays rapidly unless it is used or restudied. When a concept is learned with understanding, it can then make sense in a person's real-world experiences.

Learning with understanding means more than simply learning enough to answer a test question correctly. An investigation by Nuthall & Alton-Lee (1995) studied how science and social studies students answered achievement test questions. The students were tested before a unit, immediately after a unit, and again 12 months later. After extensive observations and student interviews, it was reported that students using their memory of relevant classroom activities to answer the same test questions 12 months later decreased from 52% to 32%. The frequency in which students used deductive reasoning from related knowledge or experience increased 12 months later from 13% to 24%. This study showed that as memory for specific classroom experiences fades, the use of other related experiences and knowledge becomes more important. While the authors of this investigation acknowledge that their results are not intended to be generalized to all students, they note that their results suggest "student learning experiences are the major determinant of how students answer achievement test items and not the content of the item itself (Nuthall & Alton-Lee, 1995, p.220)."

Lower achieving students appear to benefit the most from formative assessment (Black & Wiliam, 1998). Achievement for this population is raised overall, but the range of achievement is reduced. Formative assessment narrows the difference between the lowest and the highest summative scores. Feedback to a student that consists of only a grade does not improve learning. Students that get low marks come to believe that they will get low marks again. This negative cycle of repeated failure becomes a belief shared by both a student and a teacher (Black & Wiliam, 1998). Formative assessments allow low-achieving students to improve with effort rather than be stuck in a cycle of failure due to the presumption of lack of ability (Boston, 2002). Students that feel they have a lack of ability become discouraged and then unwilling to engage in further learning (Ames, 1992).

Attribution theory of achievement motivation has been used to study the perceived factors leading to success or failure. Human beings want to find out why certain events occur (Vispoel & Austin, 1995). People tend to look for perceived causes of unexpected successes or failures (Weiner, 1979). Weiner has identified several causal attributions, ability and effort being the most common. Other causal attributions include luck, interest, strategy, task difficulty, family influence, and teacher influence.

Weiner developed a classification system based on three properties of causal attributions- locus, stability, and control. The locus of causality is the source of the attribution. Locus can be internal, meaning the source of the attribution is characteristic of the individual, or it can be external, meaning the source of the attribution is unrelated to the individual. Ability is an example of a causal attribution with an internal locus of causality. Ability is characteristic of an individual. A poor teacher is an example of a causal attribute with an external locus; it is unrelated to the individual.

Stability, the second property of causal attributions, refers to the duration of the attribution. A causal attribution, such as ability, is considered to be stable, meaning that it is a fixed attribute over time. Effort is regarded as an unstable attribute being it can vary from one task to another.

The third property of causal attributions is controllability. Controllability refers to the degree of control that an individual has over a causal attribution. Hard work and effort are controllable dimensions of causal attributions because they are presumed to be under control of the student. Ability, on the other hand, is not a controlled causal attribution.

Academic motivation is affected by students' beliefs of causal attributions to successes and failures in school. Outcomes of success and failure do not result in the same attributions (Vispoel & Austin, 1995). Typically, students take more personal responsibility for success than failure. Successful outcomes are more often attributed to internal locus attributes such as effort and ability. Poor outcomes are often attributed to external attributes such as difficulty and luck.

High-achieving students are more likely to note ego-enhancing attributes of ability and effort to account for success. These students tend to attribute failure to a lack of effort. Low-achieving students are more likely to note ego-diminishing attributes of external factors to account for their success and low ability to account for their failures (Vispoel & Austin, 1995). Some attributions facilitate learning and some attributions diminish learning. The following table explains how attribution responses are interpreted in the dimensions of locus, stability, and control.

Table 1: Dimension Classification Scheme for Causal Attributions

	Dimension		
Attribution	Locus	Stability	Controllability
Ability	Internal	Stable	Uncontrollable
Effort	Internal	Unstable	Controllable
Strategy	Internal	Unstable	Controllable
Interest	Internal	Unstable	Controllable
Task difficulty	External	Stable	Uncontrollable
Luck	External	Unstable	Uncontrollable
Family influence	External	Stable	Uncontrollable
Teacher influence	External	Stable	Uncontrollable

Table borrowed from Vispoel & Austin (1995). Based on Weiner (1979), Elig & Frieze (1979), and Russell (1982).

Internal attributes- ability, effort, strategy, and interest produce more pride in success and shame in failure than do the external attributes- task difficulty, luck, family and teacher influence. Stable attributes- ability, task difficulty, family and teacher influence produce a greater expectational certainty than do the unstable attributes- effort, strategy, interest, and luck. This means that students are more likely to continue in a set path, whether it is success or failure, if they align the stable attributes with their outcomes. Students that correlate controllable attributes with their outcomes are more likely to be persistent and show stronger affective reaction than other students.

As noted in the implications of a study performed by Vispoel & Austin (1995), teachers need to assist students in finding ways to overcome the negative effects of ability attributions associated with failure. Successful students that attribute their success to stable attributes are more likely to continue to be successful. But the students encountering failure who attribute failure to stable attributes are likely to continue to fail. The teacher and the student start to expect the continued negative outcome. Two of the suggestions made by the authors to overcome the negative attribution tendencies support the use of formative assessment.

1. Structure the classroom around task-oriented or group-oriented goals that emphasize learning progress or mastery rather than ego goals that emphasize competition among students.

2. Encourage students to conceptualize ability as a collection of skills that may be continually improved over time.

Framework for Formative Assessment

A framework for developing formative assessment is described in Classroom Assessment and the National Science Education Standards. The primary questions that govern formative assessment are as follows.

1. Where are you going?
2. Where are you now?
3. How can you get there?

Educators and students must evaluate where they are going. In the field of science, learning for understanding is the goal. It is virtually impossible to memorize the amount of knowledge currently available. It is by far more useful for students to thoroughly understand major concepts so that these concepts might be applied to real-world situations. On a smaller scale, students in an individual classroom setting must understand the learning goals of each course. It is important that teachers have clear ideas about performance criteria and clearly relay that information to the students prior to assessing work. As noted by Sadler (1989) students must understand what constitutes quality work. The student must identify quality work in a similar manner that the teacher would identify quality work.

Before educators and students can proceed, they must determine their current position in the learning process. Time must be taken to evaluate not only the student's current level of understanding of concepts but also the teacher's current practices. As information is gathered, it is not unusual for goals to be changed based on this information.

When the current levels of understanding and methods of teaching are evaluated, a plan can then be developed to ensure that all students are given the opportunity to learn for understanding.

Each step of this framework can be achieved by incorporating methods that support formative assessment. These methods include:

1. Comment-only marking
2. Increased wait time
3. Discussion based on common experiences
4. Self-Assessment

Comment-Only Marking

Feedback to a student regarding academic progress traditionally comes in the form of a letter or a numeric grade. Although this is the most common type of feedback, it is not necessarily the most useful type of feedback. A letter or numeric grade does not help a student understand a concept more thoroughly. Comments, however, may indicate actions that a student can make to close the gap between the current level of understanding and the educational goal. Research supports the use of descriptive, criterion-based feedback as opposed to just a grade. A study conducted by Butler (1987) involved a random sampling of students and observed outcomes when the students received one of three types of feedback: (a) written remarks addressing criteria the students were previously aware of, (b) grades based on the scoring of the work, (c) both a grade and a comment. Scores on subsequent work increased for the students who received detailed comments. Scores declined for the students who received both comments and grades. The scores initially declined for the students receiving only numeric grades, but then increased between the second and third assigned tasks.

Another study performed by Crooks (1988), showed that when assessments count significantly toward a student's final grade, the student tends to ignore the feedback. This effect is reduced if students are given several opportunities to demonstrate their knowledge with only a final assessment counting toward their grade.

The research by Butler and Crooks is important to consider with respect to current research in attribution theory. Feedback that emphasizes learning goals as opposed to self-esteem leads to greater learning gains (Ames, 1992). When feedback emphasizes self-esteem, high-performing students attribute performance to effort while low-performing student attribute performance to lack of ability (Vispoel & Austin, 1995). Students that perform poorly begin to believe that they are only capable of performing poorly. Comments enable the students to focus less on competition among their grades and to focus more on improving the quality of their work.

The most useful type of feedback to a student provides specific information about errors and methods for improvement (Boston, 2002). This type of feedback enables a student to focus on understanding a concept as opposed to simply giving a correct answer. Research shows that learning can be enhanced through comments alone being placed on student work, but students ignore the comments when accompanied by a numeric grade (Black *et al.* 2002). Comments should indicate what was done well, what needs improvement, and guidelines by which to make the improvements.

Increased Wait Time

Classroom discussions are useful for teachers to evaluate students' current understanding of concepts. The frequency of teacher questioning has been shown to be positively related to student achievement (Crooks, 1988). Teacher questioning should encourage active engagement of all students, allow students to practice the material and enable students to clarify misunderstandings. A frequent problem with classroom discussions is that teachers often do not allow enough time for students to formulate a thoughtful answer (Black & Wiliam, 1998). Often teachers answer their own questions rather than allowing a few moments of silence for students to think. This lack of time results in the teacher asking questions that require little thought, with only a few "quick thinkers" participating in the classroom discussions.

Many methods may be used to allow time for all students to formulate a thoughtful response to a question. Students could be asked to write a response that can later be shared with the class. Students could be given time to discuss solutions in small groups and then designate a spokesperson for each group to relay their understanding. Teachers also need to take the time to formulate questions that are worth asking (Black *et al.*, 2002). Questions should allow students to offer rich explanations, not one-word responses. The goal of increased wait-time is not to encourage students to get the right answer the first time, but rather to get all students to offer thoughtful responses that could be used to enhance learning. It is important that the classroom environment allow all students the time and opportunity to express their understanding through classroom conversations.

The project, Science Education through Portfolio Instruction and Assessment (SEPIA), described the use of assessment conversation (Duschl & Gitomer, 1997). In this study, assessment conversation was used to formulate student understanding of key concepts. The findings were then used to adjust the instructional lessons so conceptual goals could be achieved. Because these assessment conversations are used to adjust teaching and learning, they can be considered formative assessment.

Assessment conversations occur in three general stages (Duschl & Gitomer, 1997). The first stage is "Receiving Information." It is in this stage that a public display is made of current conceptual understanding. After a question is posed, a diversity of responses is encouraged and then presented to the class. Public displays may be made through conversations, overheads, posters, charts, or any other method that allows students to express and display their current understanding.

The next stage of assessment conversation is "Recognizing Information." It is during this stage that the teacher must acknowledge the ideas in the classroom in relation to the unit of study (Duschl & Gitomer, 1997). Traditionally, responses that stray from the "best" answer are quickly constrained. In the assessment conversation method, these diverse answers are clarified through recognition and discussion.

The last stage of assessment conversation is "Using Information." In this stage the teacher uses the diverse ideas presented by the students in an effort to form a consensus view of a concept. The teacher does not dismiss incorrect ideas due to authority (Duschl & Gitomer, 1997), but rather encourages students to use reasoning to identify and clarify correct ideas.

In this model it is not enough to simply allow students to present their current understanding of a concept. They must use strategies such as critical reasoning to evaluate the adequacy of knowledge claims.

Discussion Based on Common Experiences

A study of formative assessment in the science classroom by Cowie & Bell (1999) indicated that there are basically two types of formative assessment, planned and interactive. The purpose of planned formative assessment is to obtain an understanding of student learning from the entire class (Cowie & Bell, 1999). Teachers planned tasks that would enable a student to better understand science concepts. They also planned activities so that students could share common experiences that would later be discussed in the classroom.

Interactive formative assessment occurred when individual or small groups of students interacted with the teacher. This type of assessment occurred when teachers noticed, recognized or responded to student thinking during interactions (Cowie & Bell, 1999).

Both planned and interactive formative assessments involve interaction between teacher and students to check the level of understanding. As noted earlier, learning with understanding is vital in education due to the amount of knowledge available. In order to achieve this, learners must perceive the information as relevant, important, and valued for themselves, not just useful in passing a test (Harlen, 1997). Teachers can incorporate this need for information to be relevant by employing planned and interactive formative assessment and by integrating real-world applications of the subject matter. Providing students with a common experience that demonstrates the relevance of subject matter in the world around us can then serve as a basis to lead classroom discussions. These discussions become formative in nature when they are used not only to evaluate current understanding, but also to alter the next step of instruction so as to improve learning.

An essential component of formative assessment is self-assessment (Black & Wiliam, 1998). Self-assessment can be achieved through the use of a portfolio. The term portfolio signifies a purposeful collection of work (Stecher, 1998). In the context of education there is no formal definition of a portfolio, but a portfolio in education contains documentation of an individual's achievement over an extended period of time. It tends to be cumulative in nature. It is not simply a collection of assignments, but rather an assortment containing process artifacts, documentation of achievement, self-evaluation, and analyses of learning experiences (Klenowski, 2000). Because teacher assignments differ, so do the collections of student work. Individuals take the time to reflect upon their own performance by critically evaluating the contents of their portfolio. In order for this to be done, a student must clearly understand what constitutes quality work. Teachers must take the time to ensure that students understand achievement goals. Research done by Frederikson and White (1997) showed that those students who understand learning goals and have the opportunity to reflect on their work show greater improvements in learning than those who do not. When goals are understood, students become committed learners (Black & Wiliam, 1998).

Support for portfolio use in formative assessment can be found in a study performed by the Curriculum and Instruction Department of the Hong Kong Institute of Education (Klenowski, 2000). This study evaluated the use of portfolios with first year pre-service teachers enrolled in a two-year teacher education program. Interviews conducted with the pre-service teachers indicated that the portfolios were useful in developing reflective skills. These teachers also reported that they developed independence in their learning. One pre-service teacher was quoted as saying "I learned more from the portfolio than from the lessons. Completing this assignment was harsh work, but it really helped me organize my learning and thinking."

Portfolios are not only used formatively by the learner, teachers have also adopted new strategies in response to portfolio assessments (Stecher, 1998). Just as teaching shapes assessment, assessment shapes teaching (NRC, 1996). The states of Vermont and Kentucky currently have added a portfolio component to their statewide assessment system. In Vermont, teachers reported an increase in the time they have students working in small groups as a result of portfolio findings (1998). Teachers also report an increase in the number of assignments given that require complex problem-solving skills. It is thought that scoring of the portfolios may enable teachers to achieve a better understanding of the learning process so as to result in more effective instruction. Portfolio use in the classroom is associated with greater enthusiasm for teaching, higher expectations of students, and implementation of changes in educational goals, content and procedures (1998). Because of this, teachers in Vermont characterized the portfolios as a worthwhile burden (Koretz *et al.*, 1994). The ability to self-assess is needed to become a self-directed, life-long learner (NRC,1996).

CHAPTER 3

METHODOLOGY

Research Design

A survey research design was used for this study. This form of research uncovers students' beliefs, attitudes, and perceptions about science. A comparative study was performed to unveil relationships that may exist between science achievement and attitudes. Measures of variability were also used to analyze differences in summative test scores between control and comparison groups.

Participants in the Study

The participants of this investigation were Honors Level Quantitative Physical Science (QPS) students enrolled in three high school classes. QPS is a rigorous, mathematically based freshman science course that focuses on the study of chemistry during the first semester and the study of physics in the second semester. Data was collected over the course of the first semester.

Instruments

Instruments used in this research include an Attitude Survey and a Causal Attribution Survey, both employing a Likert-type scale. Both surveys were borrowed from the Math-

Science Partnership of Greater Philadelphia. The Attitude Survey consisted of 41-items (Appendix A) designed to uncover attitudes students have about science achievement. The survey did not contain any open-ended questions. The Causal Attribution Survey consisted of nine possible events (Appendix B). Following each event there were four possible causes, the students had to choose how they felt about each of those causes.

Procedure and Data Collection

During the first semester, students were seen four days a week for a forty-two minute chemistry class and one day a week for an eighty-four minute chemistry lab. Two classes of students served as the control groups (N=22 and N=24). One class of students served as the comparison group (N=28). All three classes were taught by the experimenter.

During the first week of school baseline data was collected from all three groups. The data included survey results from the Attitude Survey and the Causal Attribution Survey.

The independent variables altered by the experimenter with the comparison group included four forms of formative assessment.

1. <u>Comment-Only Marking</u>- A numeric grade was not assigned to quizzes, homework assignments, or lab reports. These pieces of work were marked only with comments that offered specific suggestions to improve the quality of the work. Students were expected to make improvements based on the comments. This method served to give students an opportunity to improve their understanding of key concepts.

2. Increased Wait Time- All students were expected to answer questions at any given time. This method was used to broaden the range of participation as well as place the focus on thoughtful insight, not necessarily correct answers. Questions that probe a students understanding were devised prior to class time. After posing a question, a wait time was given before calling on a student to respond. The specific amount of time was not measured quantitatively, but the instructor waited until all students constructed a written response. This method was used so that all students had time to devise a meaningful answer.

3. Discussion Based on Common Experiences- Students were given an assignment that required guided research into a real-world application of specific chemistry topics. This research served to enrich classroom discussion as well as provide a purpose for learning.

4. Self-Assessment- Students kept original quizzes, homework assignments, and lab reports, along with the revisions and improvements in a portfolio. Portfolios were kept in the classroom. At the end of the first and second marking period, students wrote a reflection on their learning progress as shown in their individual portfolio.

While only the comparison group experienced formative assessment, all students were given summative assessments at the end of each unit of study.

Analysis of Data

Because the experimenter did not employ one-to-one mapping when administering surveys at the beginning or the end of the study, an independent-sample t-test was run on Statistical Package for the Social Sciences (SPSS) computer program in order to compare survey results for each class from the beginning of the study to the end of the study. This test compares the mean scores of the groups. In addition, a Bonferroni One-Way Analysis of Variance (ANOVA) was done comparing data of the three classes in the beginning of the study and then again at the end of the study. Summative test scores were analyzed using ANOVA with attention being given to the mean and standard deviation. Significant results from these analyses can be found in tables ii to viii.

Chapter 4

RESULTS AND DISCUSSION

The purposes of this study were to determine if the use of formative assessment in the science classroom improved academic achievement in a group of ninth grade honors level students; and to determine the effect of formative assessment on the attitudes these students have toward science. This chapter presents data that attempts to answer the following research questions:

1. Will the use of formative assessment in the science classroom enhance academic achievement as shown through an overall increase in summative assessment scores?

2. Will the use of formative assessment in the science classroom improve achievement as shown through narrowing the gap between high and low achievers?

3. Will the use of formative assessment improve attitudes toward science as shown through the statistical analysis of attitude and causal attributions surveys?

The data analysis was structured to reveal quantitative information to provide insight to the related research questions.

Summative Test Scores

An attempt was made to evaluate the impact formative assessment had on academic achievement as shown through an increase in summative assessment scores and a narrowing of the gap between high and low achievers. Emphasis was placed on scores from the first test of the marking period, the last test of the marking period and the semester averages. Scores were analyzed using ANOVA. The number of students and thus total scores collected vary in each group because two of the students transferred to other schools due to relocation during the study. Results of summative assessments are summarized in the following table.

Table 2: Grade summary for summative tests.

		Control Group I (N=25)	Control Group II (N=27)	Experimental Comparison Group (N=28)	p
First Test	High Score	96	97	97	0.578
	Low Score	60	62	61	
	M	76.2	78.8	77.4	
	SD	8.63	9.15	8.80	
		Control Group (N=24)	Control Group (N=27)	Experimental Comparison Group (N=27)	p
Last Test	High Score	100	100	100	0.740
	Low Score	27	60	70	
	M	91.3	92.6	90.2	
	SD	14.6	10.5	8.72	

		Control Group (N=24)	Control Group (N=27)	Experimental Comparison Group (N=27)	p
Semester Averages	High Score	98	99	98.0	0.680
	Low Score	66	70	74	
	M	84.7	86.5	85.2	
	SD	8.18	7.54	7.24	

Summative test scores do not demonstrate an overall grade improvement when comparing the control groups to the experimental comparison group. The mean test score for the first summative test was 77.4 for the experimental group and a 76.2 and 78.8 for each of the control groups. The last summative test scores for the semester showed a mean of 90.2 for the experimental group and a 91.6 and 92.6 for each of the control groups. The mean of the semester average for the experimental group was 85.2, the control groups had means of 84.7 and 86.5. The mean test scores do not show a relationship between the use of formative assessment and improved academic achievement. But a relationship can be seen between the use of formative assessment and the narrowing of the gap between high and low achieving students. The first summative assessment given in the marking period showed similar results for the difference between the high and low scores in all three groups. The final summative assessment, given after the experimental group was involved in five months of formative assessment, shows a narrowing of the gap between high and low scores. There was a 73 point difference between the high and low score on the last semester test given to the first control group (SD=14.6). The second control group showed a 40 point difference between the high and low score (SD=10.5). The comparison group only had a 30 point difference between the high and low score (SD=8.72). The semester averages also show a narrowing of the gap between the high and low scores. The difference between the high and the low scores for the first control group was 32 points and 29 points for the second control group. The difference between the high and the low scores for the experimental comparison group was only 24 points.

Attitude Survey

Most results of the attitude survey were found to be statistically insignificant when comparing responses from each group from the beginning of the study to the end of the study. The independent-sample t- test of the control groups showed a statistically significant difference in response to some survey items when comparing the responses from the beginning to the end of the study. The table below summarizes these findings.

Table 3: Attitude Survey Control Group I

Survey Statement	Survey Administration	N (Control Group 1)	Mean	Std. Deviation	Significance (Levene's Test)
An important reason why I do my science work is because I like to learn new things.	September	24	4.04	.464	0.015
	January	21	3.81	.680	
When I take a science class it is important to me that I improve science skills.	September	24	4.08	.504	0.024
	January	21	4.10	.768	
Science makes me feel uncomfortable, restless, irritable, and impatient.	September	24	3.83	.637	0.044
	January	21	3.86	.856	
Science is a worthwhile and necessary subject.	September	23	4.22	.736	0.031
	January	21	4.10	.539	

Table 4: Attitude Survey Control Group II

Survey Statement	Survey Administration	N (Control Group 2)	Mean	Std. Deviation	Significance (Levene's Test)
An important reason why I do my work in science class is because I want to get better at it.	September	26	4.15	.464	0.002
	January	26	4.23	.765	
Science makes me feel uneasy and confused.	September	26	3.92	.484	0.051
	January	27	4.15	.662	

Table 5: Attitude Survey Experimental Comparison Group

Survey Statement	Survey Date	N (Comparison Group)	Mean	Std. Deviation	Significance (Levene's Test)
An important reason why I do my work in science class is because I want to get better at it.	September	28	4.04	.508	0.019
	January	26	4.08	.744	
An important reason why I do my science work is because I like to learn new things.	September	28	3.89	.685	0.416
	January	26	4.00	.800	
Science makes me feel uncomfortable, restless, irritable, and impatient.	September	28	3.96	.637	0.58
	January	26	3.85	.784	
When I take a science class it is important to me that I improve science skills.	September	28	4.00	.667	.0469
	January	26	4.15	.675	
Science is a worthwhile and necessary subject.	September	26	4.15	.732	0.627
	January	26	4.23	.652	
Science makes me feel uneasy and confused.	September	28	4.00	.609	0.193
	January	26	4.15	.675	

The Likert-type attitude survey used provided statements in which students were to respond whether they strongly agree, agree, neither agree nor disagree, disagree, or strongly disagree with the statement. A value of five was assigned to the response of "strongly agree" scaled to a value of one assigned to the response of "strongly disagree". Some statements from the survey were reverse coded in the SPSS computer system so that a positive attitude response corresponds to a score of five and a negative attitude response corresponds to a score of one. The attitude scale was designed to evaluate attitudes regarding usefulness of science, task orientation in science, and confidence in science.

The statement from the survey regarding attitudes toward the usefulness of science that had statistical significance was "Science is a worthwhile and necessary subject." The first control group of students (N=23) responded with a mean score of 4.22 in September and a mean score of 4.10 in January (p=0.031). This shows that attitudes toward the usefulness of science worsened over time in this group. The comparison group (N=26) responded with a mean score of 4.15 in September and a mean score of 4.23 in January (p=0.627). While the results of this group are not statistically significant, it is shows that the group exposed to formative assessment did not show a diminished attitude toward the usefulness of science.

Changes in attitudes toward task orientation in the science classroom were shown to be statistically significant for two survey questions answered by the experimental comparison group (N=28). The statement, "An important reason why I do my work in science class is because I want to get better at it," had a mean score of 4.04 in September and 4.08 in January (p=0.019). But this improved attitude was also seen with control group II (N=26) with a mean score of 4.15 in September and a mean score of 4.23 in January (p=0.002). The statement "An important reason why I do my science work is because I like to learn new things," prompted a statistically significant result in control group I(N=24). The mean score for this item in September was 4.04 and the mean score in January was 3.81 (p=0.015). This response shows a diminished attitude toward task orientation in this group. In the experimental group, while the results are not statistically significant (p=0.416), the mean score in September was 3.89 and the mean score in January was 4.00, demonstrating an improved attitude toward task orientation in science. The experimental group (N=26) and one control group (N=24) both showed statistically significant results to the survey item "When I take a science class it is important to me that I improve science skills." The experimental group showed a mean score in September of 4.00 and a mean score in January of 4.156 (p=0.0469). Control group I showed a mean score in September of 4.08 and a mean score in January of 4.10 (p=0.024).

Results of this survey regarding attitudes toward confidence in science are unclear. The statement "Science makes me feel uncomfortable, restless, irritable, and impatient" produced statistically significant results (p=0.044) in control group I (N=24). The mean score in September was 3.83 and the mean score in January was 3.86. This shows an improvement in the confidence level in the control group. The experimental group did not have statistically significant results to this survey item. The statement "Science makes me feel uneasy and confused" prompted a statistically significant response in control group II. This group, (N=26) had a mean score in September of 3.92 and a mean score in January of 4.15 (p=0.051). A score closer to five demonstrates a positive response. This shows an improvement in students' attitudes about their confidence in science. While it is not statistically significant (p=0.193) , the experimental group also showed improvement in attitudes about confidence in science, mean score in September was 4.00 and the mean score in January was 4.15.

Causal Attribution Survey

A causal attribution survey was given to students in the control and comparison group at the beginning and the end of the formative assessment study. This data was collected in an attempt to evaluate the impact formative assessment had on attributions of failure or success in the science classroom. Formative assessment in the classroom was expected to enable students to overcome negative attribution tendencies. Statistically significant results were found in only one control group and in the comparison group when comparing responses from the beginning of the study to the end of the study. The following tables summarize significant results found in the independent-sample t-test.

Table 6: Attribution Survey Control Group I

Survey Statement	Survey Administration	N (Control Group 1)	Mean	Std. Deviation	Significance (Levene's Test)
Event D- You have not been able to keep up with most of the students in science class. Response-You have always had a difficult time in science class.	September	24	2.54	1.141	0.022
	January	22	2.27	0.767	
Event E- You have been able to complete your last few assignments easily. Response- You lucked into working with a helpful group.	September	24	3.00	0.885	0.041
	January	22	2.82	1.140	

Table 7: Attribution Survey Experimental Comparison Group

Survey Statement	Survey Administration	N (Control Group 1)	Mean	Std. Deviation	Significance (Levene's Test)
Event F: You were unable to understand a difficult science unit. Response- The problems were easy because they had been covered before.	September	28	3.96	0.637	0.021
	January	25	3.68	0.900	

The Likert-type causal attribution survey used provided statements in which students were to respond whether they strongly agree, agree, neither agree nor disagree, disagree, or strongly disagree with various responses for a given statement. A value of five was assigned to the response of "strongly agree" scaled to a value of one assigned to the response of "strongly disagree".

Although the first control group did not partake in formative assessment, results show changes in attributes that may facilitate learning. From the survey, the statement for Event D, "You have not been able to keep up with most of the students in science class," prompted significant results (p=0.022) from the response, "You have always had a difficult time in science class." The mean response in September (N=24) was 2.54 and in January (N=22) was 2.27. This shows that students became more confident in their ability in science class. The statement from Event E on the survey, "You have been able to complete your last few assignments easily," prompted significant results (p=0.041) from the response, "You lucked into working with a helpful group." The mean response in September (N=24) was 3.00 and in January (N=22) was 2.82. This shows that students were not as likely to attribute success with luck over time. This is also an attribution change which may facilitate learning.

The experimental comparison group showed significant results (p=0.021) for Event F from the survey, "You were unable to understand a difficult science unit," response, "The problems were easy because they had been covered before." The mean response in September (N=28) was 3.96 and the mean response in January (N=25) was 3.68. This response shows that students felt their success over time was more likely due to ability than luck or teacher influence. Ability is an internal, stable attribute which is associated with better learning outcomes than luck or teacher influence.

A Bonferroni ANOVA test was also performed to compare responses of the three groups at the beginning of the experiment and again at the end of the experiment. No statistically significant results were found from the baseline data collected at the beginning of the semester. Significant results from the data at the end of the semester, following the use of formative assessment in the comparison group, are shown in Table 8.

Table 8: Attribution Survey Bonferroni ANOVA

Survey Statement	Class	N	Mean	Significance
Event C- You had trouble with some of the problems in the daily assignment. Response- You didn't take time to look at the book.	Control Group II	27	2.59	0.022
	Experimental Comparison Group	25	3.36	

The survey statement in Event C "You had trouble with some of the problems in the daily assignment," prompted significant results from the response, "You didn't take time to look at the book." Control group II (N=27) had a mean response of 2.59 and the comparison group (N=25) had a mean response of 3.36. This statement shows that the students involved in formative assessment were more likely to attribute success with effort. Effort is an internal, controllable attribute that produces more pride in success and shame in failure. This attribute is likely to facilitate learning.

Limitations

The primary purpose of this investigation was not to generalize results, but to better understand relationships that may exist between formative assessment and achievement, attributes and attitudes toward science. The participants in the study were not randomly selected, but chosen out of convenience. It should be noted that the experimenter was also the chemistry teacher for the control and comparison groups. This relationship may have motivated students to respond in certain ways on the given surveys. A limitation to dispositional studies, such as the causal attributions survey, is the failure to evaluate a response to a real-life event (Vispoel & Austin, 1995). The survey may also not contain attributions that are pertinent to each student's scenario. This forces the student to choose a response on the survey that may not be pertinent.

Discussion

The amount of scientific information available in our modern world is increasing at an alarming rate. My own experience in healthcare as a pharmacist and in education as a high school physical science teacher made me realize that rote memorization of facts in a classroom setting cannot possibly prepare children to understand our world of science or make informed scientific decisions in life. Students do not have to pursue science as a career to require a sound scientific background. Scientific literacy is needed to make informed decisions in our daily lives. This knowledge enables us to make informed choices from comparing nutrition labels, choosing gasoline for our cars and considering healthcare options to critically evaluating scientific claims and studies for products that are marketed to us everyday. All students must be scientifically educated to function effectively in society. The findings of Black and Wiliam (1998) indicate that formative assessment in the classroom raises attainment, improves self-esteem and leads to a greater prospect of life-long learning.

As mentioned earlier, any activity that provides feedback to alter the teaching and the learning process can be a type of formative assessment. The four types utilized in this investigation were comment-only marking, increased wait time, discussions based on common experiences, and self-assessment.

Students in the comparison group were informed that their quizzes and lab reports would be graded with only comments offering suggestions for improvement. While these assignments did count for an actual grade, the grade was not immediately given on the returned assignments. Students had the option of making improvements. Initially, this was a time-consuming process. It was important students understood the criteria for success prior to submitting assignments. Class time was devoted to viewing and explaining exemplary work. Once assignments were submitted, care was taken to provide comments that would help the students improve their work without providing the answers. Students, although informed, were initially shocked to receive lab reports and quizzes with comments and no grades. As time went on, I found this process to be less time-consuming. Lab writing skills of all students improved to the point where fewer comments had to be made. While this investigation did not involve the use of open-ended questionnaires, students expressed that they liked to know errors and misunderstandings could be pointed out so improvement could be made prior to receiving a grade. One student told me that in a previous science class, he stopped submitting lab reports due to low scores. He never understood what he did or did not do to receive the low scores. He expressed fondness of this system where the criteria for success was clear and time was allotted for learning with understanding.

Increased wait time was the second form of formative assessment used in this investigation. The students in the comparison group were asked not to raise their hands to respond to questions posed to the class. Prior to class, I attempted to devise meaningful questions that would indicate the level of the students' understanding. This information would then be used to alter subsequent lessons. These questions were often difficult to devise. I found it helpful to work with colleagues who teach the same or similar courses. Once the questions were devised and posed to the class, students were given time to write their response in their notes. Once I saw that students were finished thinking and writing, I would select a student for an answer. Students were encouraged to respond to the best of their ability. The focus of discussion was not on whether a response was correct or incorrect. Answers given by students were used to generate discussion and opinions from other students. Again, while not formally documented, students did express that they felt responsible for being attentive at all times knowing that all students were expected to participate. One student told me that while he was very shy in most classes; he was comfortable speaking in science class because students respected each others responses. Perhaps this was because the students had time to think and were required to critically comment on responses given by others.

The third form of formative assessment was discussion based on common experiences. In order for students to learn for understanding, they must feel the material is relevant to their lives. I found providing a common experience for the students challenging. The students attended class daily for only forty-two minutes, with the exception of the weekly lab, consisting of eighty-four minutes. With so much curriculum content required, I found it almost impossible to find time to provide a common experience to the students which would lend relevance of the material. Because of time constraints, I chose to give short-term assignments that students completed on their own and then devoted time in class for discussion and relevance to real life. Appendix D provides assignments that were used. While it is impossible for me to determine whether this method will create life-long learners, I was pleased with the relevance students found regarding knowledge of the metric system. Freshman science students are expected to use and understand the metric system. Metric units are taught as an initial lesson and built upon throughout the course. Each year, students express disinterest in the metric system noting that it is not used widely in the United States. At their age and level of experience, they have a hard time believing that it is internationally used in science. After assigning the independent work regarding the loss of the Mars Climate Orbiter due to the error between the metric and English system, I noticed that students no longer questioned why they were required to understand the metric system.

The last form of formative assessment used was self-assessment. Students were required to maintain a portfolio in the classroom that demonstrated improvement and understanding of key concepts over time. Students kept track of their original and improved assignments in the portfolio. It provided them an organized method of reflecting upon their own learning. Appendix E provides the portfolio scoring rubric which explains more clearly the responsibility of the students. While I feel that portfolios are useful as a means of self-assessment and reflection, I found them difficult to use in our setting. Portfolios were kept in the classroom so that I could periodically review them and to ensure that students would not misplace them. However, due to scheduling issues, the comparison group did not meet in the same classroom everyday which means that the portfolios were not always readily available. In addition to this problem, other teachers and classes also met in the classroom in which the portfolios were stored. Also, the amount of curriculum that is required to be covered did not allow us the proper amount of time needed to work on portfolios in the classroom. Portfolios would be more useful if the class met everyday in the same room and if there was more flexibility in the curriculum so as not to be pressured by time.

While I found the initial introduction of these forms of formative assessment frustrating and time-consuming, I am pleased with the changes that have occurred in the classroom. Students became more responsible for their learning. Low-achievers were not expected to remain low-achievers. Opportunity, guidance, and time was given to allow all students to learn to the best of their ability. Students learned to think critically about each others responses and work. Relevance was provided for understanding major concepts. I plan on continuing and improving the practice of formative assessment in the classroom.

Chapter 5

CONCLUSION

Formative assessments can take on many forms. Provided the assessments are useful in improving teaching and learning, many activities can have a formative nature. This investigation employed four forms of formative assessment in the chemistry classroom. These forms were:

1. Comment-only marking
2. Increased wait time
3. Discussion based on common experiences
4. Self-assessment

Results showed a possible relationship between formative assessment and a narrowing of the gap between high and low achieving students. This investigation also showed a possible relationship between formative assessment and improved attitudes toward the usefulness of science and task orientation in science. The causal attribution survey demonstrated a possible relationship between success in science and attributes of ability and effort. While these results cannot be applied to the general population, they do show that possible relationships exist.

This investigation made use of test scores and surveys in a small, homogeneous sample of students. All students were honors-level. No open-ended questionnaires or interviews were conducted. Future investigations are needed to observe the effect of formative assessment on other academic levels of students. It would also be useful to collect qualitative data regarding the students' perceptions of their learning when incorporating formative assessment into the classroom. The variety of approaches makes formative assessment useful in other content areas. This investigation looked at the effect of formative assessment in only a science setting. Future studies would be useful to determine whether formative assessment is effective in improving learning and attitudes in other disciplines.

REFERENCES

Ames, C. (1992) Classrooms: Goals, structures, and student motivation. *Journal of Educational Psychology*, 84 (3): 261-271.

Bangert-Drowns, R., Kulik, Chen-Lin, Kulik, J., Morgan, M.T. (1991) The instructional effects of feedback in test-like events. *Review of Educational Research*, 61 (2): 213-238.

Black, P. J. & Wiliam, D. (1998) *Inside the black box: raising standards through classroom assessment* (London, King's College London School of Education).

Black, P.J. & Wilaim, D. (1998b) Assessment and classroom learning. *Assessment in Education* 5 (1): 7-74.

Black, P. J., Harrison, C., Lee, C., Marshall, B. and Wiliam, D. (2002) *Working Inside the Black Box: Assessment for Learning in the Classroom*. London: Department of Education and Professional Studies, King's College.

Black, P., Harrison, C., Lee, C., Marshall, B. & Wiliam, D. (2003) *Assessment for learning: putting it into practice* (Buckingham, Open University Press).

Boston, C. (2002) The Concept of Formative Assessment ERIC Clearninghouse on Assessment and Evaluation College Park MD. ED470206

Broadfoot, P. & Black, P. (2004) Redefining assessment? The first ten years of Assessment in Education. *Assessment in Education*, Vol 11, No. 1.

Butler, (1987) Task-involving and ego-involving properties of evaluation: effects of different feedback on motivational perceptions, interest and performance. *Journal of Educational Psychology* 79(4): 474-482.

Cowie, B. & Bell, B. (1999) A model of formative assessment in science education. *Assessment in Education: Principles, Policy & Practice*, Vol 6, Issue.

Crooks, T. (1988) The impact of classroom evaluation practices on students. Review of Educational Research, Vol. 58, No.4, 438-481.

Dixon, H. & Ecclestone, K. (2003) Potential benefits of formative assessment in general practice education. *Education for Primary Care* 14: 115-25.

Duschl, R.A., Gitomer, D.H. (1997) Strategies and challenges to changing the focus of assessment and instruction in science classrooms. *Educational Assessment* 4(1), 37-73.

Frederiksen, J.R., and White, B.J. (1997) Reflective assessment of students' research within an inquiry-based middle school science curriculum. Paper presented at the annual meeting of the American Education Research Association, Chicago, Il.

Harlen, W., James, M. Assessment and Learning: Differences and relationships between formative and summative assessment. *Assessment in Education: Principles, Policy & Practice* 4(3), 365-380.

Klenowski, V. (2000) Portfolios: promoting teaching. *Assessment in Education, Policy & Practice* 7(2).

Koretz, D., Stecher, B., Deibert, E. (1992) The Vermont Portfolio Assessment Program: Interim report on implementation and impact, 1992-1992 school year, CSE Technical Report 350 (Los Angeles, Ca., CRESST/UCLA)

National Research Council (2001). Classroom Assessment and the National Science Education Standards, edited by J.M. Atkin, P. Black, and J. Coffey. Washington, D.C.: National Academy Press (Browse online at: http:www.nap.edu/catalog/9847.html).

Nuthall, G. & Alton-lee, A. (1995). Assessing Classroom Learning: how students use their knowledge and experience to answer classroom achievement test questions in science and social studies. *American Educational Research Journal* 32(1), 185-223.

Sadler, D.R., (1989). Formative assessment and the design of instructional systems. *Instructional Science* 19:119-144.

Stecher, B., (1998) The local benefits and burdens of large-scale portfolio assessment. *Assessment in Education: Principles, Policy & Practice* (5)3.

Vispoel, W.P., Austin, J.R. (1995) Success and Failure in Junior High School: A critical incident approach to understanding students' attributional beliefs. *American Educational Research Journal* 32(2), 377-412.

Weiner, B. (1979). A theory of motivation for some classroom experiences. *Journal of Educational Psychology*, 71, 3-25.

Wiliam, D., Lee, C., Harrison, C. & Black, P. (2004) Teachers developing assessment for learning: impact on student achievement. *Assessment in Education,* Vol. 1, No.1.

APPENDIX A

ATTITUDE SURVEY

Directions. We are interested in learning how you think about science and in learning how your thoughts about science change during your years in high school. Your responses to the following items will help us understand how you think about science. There are no right or wrong answers. Just tell us what you think.

For items 1 through 41, please read each item carefully. Find the matching number on your answer sheet and mark the response that best describes your feelings about the item. On the answer sheet, mark response "A" if you STRONGLY AGREE, "B" if you AGREE, "C" if you NEITHER AGREE NOR DISAGREE, "D" if you DISAGREE, and "E" if you STRONGLY DISAGREE.

	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
1. I like science class work best when it really makes me think.	A	B	C	D	E
2. Science is of no relevance to my life.	A	B	C	D	E
3. I like science class work that I'll learn from even if I make a lot of mistakes.	A	B	C	D	E
4. I get a sinking feeling when I think of trying science problems.	A	B	C	D	E
5. I think I could handle more difficult science.	A	B	C	D	E
6. For some reason even though I study, science seems unusually hard for me.	A	B	C	D	E
7. I usually have been at ease during science tests.	A	B	C	D	E
8. When I take a science class, one of my goals is to master a lot of new skills.	A	B	C	D	E
9. I have a lot of self confidence when it comes to science.	A	B	C	D	E
10. My mind goes blank and I am unable to think clearly when working on science.	A	B	C	D	E
11. I do my science class work because I'm interested in it.	A	B	C	D	E
12. An important reason why I do my work in science class is because I want to get better at it.	A	B	C	D	E

	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
13. I don't think I could do advanced science.	A	B	C	D	E
14. I'm not the type to do well in science.	A	B	C	D	E
15. Most subjects I can handle OK, but I have a knack for messing up science.	A	B	C	D	E
16. I'll need a firm mastery of science for my future work.	A	B	C	D	E
17. Generally I have felt secure about attempting science.	A	B	C	D	E
18. I'm no good at science.	A	B	C	D	E
19. Knowing science will help me earn a living.	A	B	C	D	E
20. An important reason why I do my science class work is because I like to learn new things.	A	B	C	D	E
21. I can get good grades in science.	A	B	C	D	E
22. Taking science is a waste of time.	A	B	C	D	E
23. Except for those who are going to be scientists or engineers, most students would rather take other courses than science.	A	B	C	D	E
24. I almost never have gotten nervous during a science test.	A	B	C	D	E
25. Science has been my worst subject.	A	B	C	D	E

	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
26. Science makes me feel uneasy and confused.	26. A	B	C	D	E
27. I study science because I know how useful it is.	27. A	B	C	D	E
28. One of my goals in science class is to learn as much as I can.	28. A	B	C	D	E
29. When I take a science class, it is important to me that I improve science skills.	29. A	B	C	D	E
30. Science usually makes me feel uncomfortable and nervous.	30. A	B	C	D	E
31. When I take a science class, it is important to me that I learn a lot of new concepts.	31. A	B	C	D	E
32. I am sure that I can learn science.	32. A	B	C	D	E
33. A science test would scare me.	33. A	B	C	D	E
34. I will use science in many ways as an adult.	34. A	B	C	D	E
35. Science doesn't scare me at all.	35. A	B	C	D	E
36. Science makes me feel uncomfortable, restless, irritable, and impatient.	36. A	B	C	D	E
37. An important reason why I do my science class work is because I enjoy it.	37. A	B	C	D	E
38. Science is a worthwhile and necessary subject.	38. A	B	C	D	E

	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
39. It's important to me that I thoroughly understand my science class work.	39. A	B	C	D	E
40. For most jobs it is more important to be well rounded and broadly educated than to know science.	40. A	B	C	D	E
41. I see science as a subject I will rarely use in daily life as an adult.	41. A	B	C	D	E

APPENDIX B

CAUSAL ATTRIBUTION SURVEY

Directions. You are going to read about an event which could have happened to you. In addition, you are going to see four possible causes of that event. You are going to respond to how you feel about whether the causes listed could really explain the event if it had happened to you. Each event and its possible causes are listed in a group. In each group an event is followed by four possible causes. You are to read the event carefully and then respond to how you feel about each of the causes of the event.

	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
EVENT A: A part of your science homework was wrong.					
1. You just can't seem to remember to do the steps.	A	B	C	D	E
2. You were careless about completing it.	A	B	C	D	E
3. The part marked wrong included a step which was more difficult.	A	B	C	D	E
4. You were unlucky.	A	B	C	D	E
EVENT B: You got the grade you wanted for the semester in science class.					
5. The content of the class is easy.	A	B	C	D	E
6. You spent a lot of time each day studying science.	A	B	C	D	E
7. The teacher is good at explaining science.	A	B	C	D	E
8. You have a special talent for science.	A	B	C	D	E
EVENT C: You had trouble with some of the problems in the daily assignment.					
9. There was no time to get science help because of a schedule change for the day.	A	B	C	D	E
10. You don't think in the logical way that science requires.	A	B	C	D	E
11. You didn't take time to look at the book.	A	B	C	D	E
12. They were difficult word problems.	A	B	C	D	E

	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
EVENT D: You have not been able to keep up with most of the students in science class.					
13. Students sitting around you didn't pay attention.	A	B	C	D	E
14. You haven't spent much time working on it.	A	B	C	D	E
15. The material is difficult.	A	B	C	D	E
16. You have always had a difficult time in science classes.	A	B	C	D	E
EVENT E: You have been able to complete your last few assignments easily.					
17. The problems were more interesting.	A	B	C	D	E
18. The effort you put into homework at the beginning helped.	A	B	C	D	E
19. You're a very able science student.	A	B	C	D	E
20. You lucked into working with a helpful group.	A	B	C	D	E
EVENT F: You were able to understand a difficult science unit.					
21. The way the teacher presented the unit helped.	A	B	C	D	E
22. Your ability is more obvious when you are challenged.	A	B	C	D	E
23. You put hours of extra study time into it.	A	B	C	D	E
24. The problems were easy because they had been covered before.	A	B	C	D	E

	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
EVENT G: You received a low grade on a chapter test.					
25. You're not the best student in science.	A	B	C	D	E
26. You studied, but not hard enough.	A	B	C	D	E
27. There were questions you'd never seen before.	A	B	C	D	E
28. The teacher had spent too little class time on the chapter.	A	B	C	D	E
EVENT H: You have passed most tests with no trouble.					
29. The teacher made learning science interesting.	A	B	C	D	E
30. Like everyone says, you're talented in science.	A	B	C	D	E
31. But, you spent hours of extra time on this class.	A	B	C	D	E
32. The units were the beginning group, easy ones.	A	B	C	D	E
EVENT I: There were times when you were not able to solve science problems.					
33. It was a task which didn't interest you.	A	B	C	D	E
34. Despite studying you didn't understand it well enough.	A	B	C	D	E
35. Your friends' lack of attention in class was part of the problem.	A	B	C	D	E
36. But then you didn't spend time doing homework.	A	B	C	D	E

APPENDIX C

TEST SCORES

SUMMATIVE TEST SCORES

Period 2 Test Summary (Control Group I)

	Marking Period I				Marking Period II					
	Measurement Test	**Matter & Energy Test**	**Atomic Structure Test**	**Compound Naming test**	**Mole test**	**Chemical Equations Test**	**Stoichiometry Test**	**Marking Period I**	**Marking Period II**	**Semester Average**
	70	62	91	82	52	89	95	80	76	78
	75	70	75	46	82	66	99	72	75	74
	69	74	60	78	86	82	95	71	83	77
	72	100	97	98	100	92	100	94	96	95
	70	91	93	96	87	97	91	90	94	92
	86	85	95	92	92	94	95	92	95	94
	85	94	95							
	96	90	94	80	83	93	99	91	92	92
	78	86	97	94	90	90	99	80	77	79
	64	59	94	84	70	86	88	78	85	82
	82	86	95	94	79	98	87	82	82	82
	71	93	73	78	66	72	90	78	78	78
	82	93	94	98	96	94	96	91	95	93
	66	68	72	88	70	66	96	72	75	74
	70	65	64	86	70	79	87	75	80	78
	75	88	87	82	78	89	89	86	86	86
	83	91	83	80	70	79	91	85	82	84
	70	91	95	88	70	92	99	87	90	89
	80	84	90	94	87	79	98	90	91	91
	89	98	100	98	92	99	100	98	97	98
	76	82	90	74	83	90	89	85	83	84
	70	97	85	94	70	70	83	85	78	82
	81	83	93	98	83	90	98	90	91	91
	86	91	96	100	97	98	100	94	94	94
	60	72	81	70	62	77	27	71	60	66
Average	76.2	83.72	87.56	86.33	79.79	85.88	91.29	84.04	84.79	84.42

Period 5 Test Summary (Control Group II)

	Marking Period I				Marking Period II					
	Measurement Test	Matter & Energy Test	Atomic Structure Test	Compound Naming Test	Mole Test	Chemical Equations Test	Stoichiometry Test	Marking Period I	Marking Period II	Semester Average
	62	84	85	78	61	83	74	75	75	75
	70	63	88	68	70	78	88	76	76	76
	70	84	90	68	70	76	73	82	80	81
	97	98	99	100	93	96	100	99	98	99
	79	90	94	82	84	97	100	88	93	91
	82	79	92	90	82	95	96	88	92	90
	70	70	88	70	66	76	93	78	80	79
	90	91	96	92	97	96	100	95	97	96
	76	87	91	88	71	91	100	88	90	89
	82	81	96	80	77	98	99	88	91	90
	71	70	81	70	70	71	91	77	77	77
	87	76	88	94	88	91	95	87	91	89
	82	83	98	100	94	100	100	92	95	94
	75	80	83	54	70	85	94	76	80	78
	70	89								
	70	73	92	70	66	90	84	80	78	79
	80	85	94	98	82	89	93	91	90	91
	86	80	93	90	99	99	100	90	98	94
	97	87	97	100	79	97	99	94	94	94
	71	68	90	82	70	88	100	82	90	86
	87	85	95	98	100	96	100	94	96	95
	76	78	81	84	70	89	98	83	88	86
	70	71	94	90	70	82	100	84	85	85
	81	77	91	78	74	100	100	86	91	89
	88	83	94	98	74	97	100	90	93	92
	70	80	98	90	70	83	85	82	78	80
	89	93	87	82	98	95	79	90	90	90
				74	74	72	60	68	71	70
Average	78.81	80.93	91.35	84.00	78.48	89.26	92.63	85.30	87.30	86.48

Period 8 Test Summary (Experimental Group)

	Marking Period I				Marking Period II					
	Measuement Test	Matter and Energy Test	Atomic Structure Test	Naming Test	Mole Test	Chemical Equations Test	Stoichiometry Test	Marking Period 1	Marking Period 2	Semester Average
	97	102	96	100	97	91	100	99	96	98
	71	63	82	70	70	86	96	73	83	78
	61	70	83	78	70	74	72	78	75	76
	70	76	93	80	70	69	86	83	76	80
	77	84	89	70	83	71	89	81	82	82
	70	75	78	74	70	70	96	79	82	81
	76	65	74	72	70	70	71	74	75	75
	72	76	87	84	86	88	95	84	90	87
	83	86	90	94	79	88	84	88	83	86
	92	95	98	96	79	90	99	95	90	93
	70	85	96	78	70	70	87	84	80	82
	70	67	77	70	70	70	84	73	74	75
	70	82	96	96	79	93	89	86	83	85
	74	87	94	70	88	72	81	84	82	83
	73	90	91	90	70	95	94	88	87	88
	72	86	66	80	74	70	99	82	85	84
	80	90	97	98	80	91	90	94	93	94
	88	90	95	90	97	96	98	94	98	96
	78	84	89	80	68	96	96	85	83	84
	82	90	98	98	82	90	91	94	91	93
	86	86	100	90	82	96	96	93	93	93
	88	71	96	98	81	93	99	90	91	91
	90	96	97	100	70	98	96	96	92	94
	70	74	81	70	71	70	88	67	80	74
	89	77	92	70	72	71	91	80	80	80
	70	87	85	70	72	70	70	81	75	76
	70	93	95	92	93	97	99	89	95	92
	78	74	99							
Average	77.39	82.18	89.79	83.63	77.52	82.78	90.22	84.96	84.96	84.91

APPENDIX D

ASSIGNMENTS-RELEVANCE OF SUBJECT MATTER

Name ____ Pd. _____

Log onto www.thinkquest.org
Click on Library (in the upper, right corner)
Search for: M & M Mess up: Mars/Metric
Click on "Visit site"

1. What was the purpose of the Mars Climate Orbiter mission?

2. Explain what caused the mission to fail.

3. The main body of the spacecraft of the Mars Climate Orbiter was 2.1 meters in height. Convert this height into feet. (2.54cm = 1 in.)

4. The total mass of the spacecraft and the fuel was 629kg. What is the mass in grams? In pounds?

5. The closest that the Mars Climate Orbiter could safely come to the Martian surface was 93 kilometers. How many miles is this equal to?

6. Describe how problems like this, which lead to the destruction of the Mars Climate Orbiter, could be avoided in the future.

7. Do you feel that there is a need for a universal system of measurement? Explain.

QPS Assignment Isotopes Name ______________________ Pd.#___

Log onto the following website:
http://ie.lbl.gov/education/isotopes.htm

Information About Isotopes

1. How are isotopes of an element the same? How are they different?

2. What is meant by "half-life?"

The ABC'S of Nuclear Science-Basic Nuclear Science

The nucleus of an atom is less than ____________ the size of the atom; yet the nucleus contains more that ____% of the mass of the atom. The subatomic particles found in the nucleus are the _________ and the _________. These particles are held together by a strong _________________.

Approximately how many stable isotopes are found among the elements? Unstable isotopes?

Explain how fusion differs from fission?

http://www.chem.duke.edu/~jds/cruise_chem/nuclear/uses.html

1. **americium-241**
    a. What is this isotope used for?

    b. How many protons, neutrons and electrons are found in this isotope?

    c. What is the atomic number of this isotope?

2. **Carbon-14**
    a. What is this isotope used for?

    b. What is the half-life of Carbon-14?

3. **Cobalt-60**
    a. Several meats are irradiated with Cobalt-60. What is the purpose of this process?

    b. In other countries some fruits and vegetables are irradiated with Cobalt-60. What is the reason for this? Why is this procedure not normally done in the United States?

4. **Explain how isotopes may be useful in agricultural studies.**

QPS Chemistry Project **Due Date: ______________________**

The objective of this project is to research a common household chemical, integrate multiple concepts learned throughout the year, and create a pamphlet/booklet summarizing your findings.

The Chemistry of [EACH STUDENT ASSIGNED A COMPOUND]

Include the following:

1. **Chemical Name & Formula**
   - Explain whether chemical is an ionic or a molecular compound, relate to atomic structure.
   - Shape, geometry, or structure of the compound.
   - Common name.

2. **Chemical Quantities**
   - Molar mass- show units and how it is determined.
   - Calculate percent composition of each element in the compound.
   - Is the chemical formula an empirical formula, molecular formula, or both?

3. **Chemical Reactions**
   - Identify/show a balanced chemical reaction that the compound may be involved in. (This may be the production of the compound or any reaction you are able to show).
   - Identify/explain reaction type (synthesis, decomposition, single-replacement…)

4. **Stoichiometry**
   - Demonstrate, using the above balanced chemical equation, your ability to perform:
     1. Mole-mole calculations
     2. Mass-mass calculations
     3. Limiting reagent identification
     4. Percent yield

5. **Historical use/discovery of the compound.**

6. **Current uses of the compound/how the compound works.**
   Pros/cons, precautions

7. **Methods of commercial production**

APPENDIX E

PORTFOLIO SCORING RUBRIC

Marking Period I **Portfolio Due Date :** ______________________ **Name** ______________________

Include the following:

1. *Quizzes, Tests, Mini Lab Worksheets & Formal Lab Reports*. For any assessment below 70%, include corrections made as well as explanations of why errors were made. Also include re-tests if any were taken.

2. Write a *reflection on your favorite lab* activity from the first marking period. Include the reason you chose it and explain what you learned from it.

3. Proof of understanding a major concept from the first marking period. You may accomplish this in one of two ways:

   a. *Create a visual* (picture, diagram, drawing, etc.) on a sheet of paper that explains a major concept or theme that was learned. Be creative.

   OR

   b. *Write a letter* to a classmate that explains a major concept your learned this marking period. Be sure to be descriptive and include examples so your classmate also understands the concept.

Portfolio Scoring Rubric

Categories	Level 4	Level 3	Level 2	Level 1
Content -Original work -Revision of work	• Required documents contain thorough information • Thorough understanding of key concepts is demonstrated	• Required pieces contain complete information • Sufficient understanding of key concepts is demonstrated	• Some required pieces lack complete information • Some understanding of key concepts is demonstrated	• Required pieces contain minimal information • Limited understanding of key concepts is demonstrated
Reflection	• Reflection shows strong evidence of thoughtfulness and deep insight	• Reflection shows sufficient evidence of thoughtfulness and insight	• Reflection shows some evidence of thoughtfulness or insight	• Reflection shows minimal evidence of thoughtfulness or insight
Organization	• Portfolio demonstrates high degree of complete organization	• Portfolio demonstrates sufficient amount of organization	• Portfolio is somewhat organized	• Portfolio lacks clear organization
Growth	• Many articles demonstrate strong evidence of growth and learning over time.	• Several articles demonstrate evidence of growth and learning over time.	• Some articles demonstrate evidence of growth or learning over time.	• Articles demonstrate minimal evidence of growth or learning over time.