EFFECTS OF USING FORMATIVE ASSESSMENTS TO INCREASE ACHIEVEMENT IN SECOND GRADE SCIENCE

by

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

In this investigation formative assessments were implemented with the purposes of improving student conceptual understanding in science and instructional practices to inform teaching decisions and planning. Students showed improvement following the execution of formative assessment techniques. Students also demonstrated and expressed more positive attitudes toward science. Instructional practices, which informed teaching decisions, increased in frequency.

INTRODUCTION AND BACKGROUND

Arlee Public School is a K-12 district located at the southern end of the Flathead Indian Reservation in Arlee, MT. The school serves a culturally diverse population of 285 K-8 students. Of these students, 71% are Native American, predominately of the Salish, Kootenai, and Pend d`Oreille tribes. Sixty-five percent are economically disadvantaged, 40% are English Language Learners (ELLs), and 72% are on free and reduced lunch. African American, Hispanic/Latino, Asian, and European cultures make up the remaining 29% of the school population (D. Smith, personal communication, November 20, 2011). All of my students receive Title-1 services for math and reading. Three students were identified for Special Education. During the study we used Harcourt School Publishers as the program to support our district science curriculum standards.

The students selected for this action research project are from my second grade class. The class consisted of seventeen students, eight girls and nine boys. The students' ethnic backgrounds are diverse with 78% Native American/Alaskan Indian, 9% percent Asian, and 13% of European heritages. According to district assessments, the easy-CBM for math, and Dibels for reading, my students' academic abilities and conceptual understanding of math and reading ranged from the beginning of first grade level to the beginning of fourth grade. Social maturity similarly had a wide range.

In an effort to fully understand the impact of my teaching strategies and students' learning, the focus of this action research was on the use of formative assessments. It has been proposed that assessments that set clear purposes and targets, sound design, effective communication, and student involvement build good classroom practices for learning (Chappuis, 2009) (Appendix A).

It has been suggested that assessment strategies which lack cultural, linguistic, and placed-based components may hinder their use in providing accurate information about Indigenous student learning (Nelson-Barber and Trumbull, 2007; Aikenhead and Michell, 2011). Concern about the use of formative assessment in my classroom led me to my primary focus question: What impact does the use of formative assessment have on my classroom community of students and their conceptual understanding in Earth science? Furthermore, I also explored the question: What effect does the use of formative assessments have on my instructional practices to inform my teaching?

CONCEPTUAL FRAMEWORK

In educational terms, assessment can be described as a considered opinion about a students' understanding based upon his/her performance in that area of study (Soukhanov, 2004). Assessment can also be the process or operation of gathering information to inform teaching and learning decisions (Stiggins & DuFour, 2009). Linking different types of assessment, both summative and formative, throughout the learning process for both the teacher and the student can ensure that the best evidence is used to determine student success (Bakula, 2010; Clarke, 2008; Britton, 2011).

The history of formative assessment can be traced to the 1960's when Scriven suggested that the terms formative and summative be used to distinguish between different types of evaluation (Clarke, 2008). Formative assessment became associated with that assessment that informed both teachers and learners during the instruction process, as opposed to summative assessment which constitutes assessment that occurs at the end of instruction.

Students who play an active role in formative assessment tend to be more likely to become life-long learners. Black and Wiliam (1998) offered evidence that when formative assessment is used in the classroom, student learning will improve. Further, teachers who took risks and tried using formative assessments, even if it is only in one area, gained confidence in their ability to implement valid assessments and began to use more formative assessments in other content areas (Black, Harrison, Lee, Marshall & Wiliam, 2004). Teachers who design lessons that involved students with the use of effective communication and involvement in the tracking and setting of goals will have a deeper conceptual understanding of science concepts (Chappuis, 2009).

Assessments can be described as either formative and/or summative; it is how the assessments are used that determines their purpose (The Assessment Reform Group, 2006). Every assessment can be formative, if the teacher is able to take the student from where they are in their learning cycle and increase their knowledge and/or skills. Teachers that use formative assessments to improve the quality of student learning through better techniques in the classroom will expand and increase their ability to better serve their students (Angelo & Cross, 1993).

A variety of methods and techniques are used to evaluate student performance and achievement in all content subject areas and social behaviors. Everyday classroom assessment is unique to each classroom community and culture. Ideally, classroom assessment is on-going. It provides the teacher with current data about student learning

(Keeley, et al., 2005; Lee & Abell, 2007). There are many ways to describe the varied categories of assessment, from diagnostic, to formative, and summative (Sterling, 2005).

Diagnostic assessment occurs before the unit of study begins (Sterling, 2005). It is here that the teacher will determine what students know about the concepts that will be taught and uncover any pre or misconceptions. Diagnostic assessments come in many forms, including minute papers, background knowledge charts, focused listing, misconception/preconception check, thumbs up and down, red/green cards, and background knowledge probes to mention a few (Angelo & Cross, 1993).

Formative assessments occur throughout the instruction of any unit of study and monitor student progress (Ebert-May, Batzli, & Lim, 2003; Sterling, 2005; Clarke, 2008; Angelo & Cross, 1993). Formative assessment provides explicit instruction to assist learners in how to improve their skills and deepen their understanding of subject content. When assessment is used to revise a curriculum, change teaching style, or provide feedback to students, it is considered formative. Classroom assessment techniques, such as problem and project based learning, self-, peer-, and teacher evaluation and feedback are strategies to integrate formative assessment into your classroom. These strategies work well in all content areas to inform instruction, identify student understanding and motivate students to become independent learners (Angelo & Cross, 1993; Atkin & Coffey, 2003; Clarke, 2008; Keeley, Eberle, & Farrin, 2005; Trauth-Nare & Buck, 2001).

Summative assessment takes place directly at the end of a unit of study or scheduled times throughout the year, to determine what students have learned (Clarke, 2008; Sterling, 2005). It enables teachers to see whether or not students have mastered content skills or met grade level benchmarks determined by the school district. Decisions about report cards, grade promotion and graduation are based upon standardized summative assessments (Nelson-Barber & Trumbull, 2007). These assessments can be district based within curriculums or national standardized tests such as the standardized Montana criterion reference testing that takes place each year in Montana for grades 3, 8 and 10 (Montana Public Instruction, 2012).

Pertinent information gathered with the use of assessments on performance is provided at each level for students and teachers, administrators, and school boards. This information is used to determine and report accomplishments and deficits of students, teachers, and the school district (Stiggins & DuFour, 2009). The impact of using assessments formatively, first within a classroom and then within a district can transform how we think as a society about learning (Black et al., 2004). Since assessment is used as an organized process for gathering information about the educational system, the information gained through assessment can be used to guide classroom instructional decisions, hold schools accountable for student achievement, and monitor and evaluate educational programs (Coffey, Douglas, & Sterns, 2008).

The philosophy of using assessments formatively has the potential to change how teachers and students work together to improve the quality of learning for both (Black et al., 2004). Students will become active learners, who take responsibility for their learning. Teachers will become active listeners, using reflection and feedback, to gather information which is expressed in their instruction (Black et al., 2004).

Incorporating culturally valid assessments in the classroom is imperative for all students, particularly in underperforming and/or underrepresented students, such as Native American students, whose traditional ways of learning and demonstrating proficiency may differ significantly from the mainstream school. Working with teachers, students, and the local communities to look at how indigenous students have developed ways of knowing, teaching, and learning in their lives outside of school will inform classroom teachers and school districts to be better at assessing student performance and success in school and in real life (Nelson-Barber & Trumbull, 2007).

METHODOLOGY

My action research covered two units of study in Earth science and met the Montana Science Content Standards for Earth and Space science for second grade. Instruction and data collection occurred over a three month period beginning in January 2012 and concluding in April 2012. We used Harcourt School Publishers as the program to support our district science curriculum standards. The Earth Science Units were titled “Weather” and “The Solar System.” The research methodology for this project received an exemption by Montana State University's Institutional Review Board and compliance for working with human subjects was maintained.

For the two units that were a part of this study, the first unit on weather was taught according to Harcourt School Publishers program guidelines. The second unit on the solar system was taught with the addition and integration of formative assessments. Each unit consisted of four lessons. Teaching strategies implemented during each lesson focused on improving student understanding of Earth science concepts. Classroom practices included teacher strategies such as setting a clear purpose, writing concise learning targets, sound lesson design, and student involvement in which the students were involved in their own assessments. Example activities included creation stories, clay models of the solar system, guest speakers, NASA video conferencing, artistic representations of the causes of the seasons and day/night and the use of classroom assessment techniques.

To begin the research process, I administered the Test of Science-Related Attitudes (TOSRA) to my students (Appendix B). The TOSRA was used to obtain information about the science-related attitudes of individual students and the whole class. The TOSRA scoring system made it possible to obtain a profile of attitude scores for groups of students. The normalized gain was used to measure the net gain or loss of improvement for the four distinct science-related attitudes. TOSRA has been carefully developed and extensively field tested and has been shown to be highly reliable (Fraser, 1981).

To determine learning style preferences, all students were interviewed at the beginning and end of “The Solar System” unit (Appendix C). Specifically, students were asked to explain in their own words what types of learning style preferences enabled them to best express their conceptual understanding for science. Responses were tallied and quantified for each category. The categories were: How do you like to learn?, Is it small/whole group, independently, with the teacher or in pairs?, Do you like to build projects to explain your understanding of the science concept(s)?, Do you like to draw/illustrate/label artistic pictures of your understandings of science concepts?, and The normalized gain was used to measure the net gain or loss of learning style preferences for each category. This enabled me to adjust my teaching strategies and assignments to ensure that I was meeting the learning styles of my students prior to instruction.

Additionally, a Smiley Face Attitudes Survey Assessment was used to determine students' responses to a series of statements and questions about the unit, the assessments used, and the class dynamics of working groups was administered (Appendix D). Responses were evaluated using Excel. Students used a three point scale to indicate their attitudes and perception toward what and how they learned. A point value of 3 was designated by a smiling face, while a point value of 1 was designated by a frowning face.

The Student Traffic Light Tracking Chart (STLTC) was used to determine at which time a student could explain a new science concept(s) (Appendix E). The STLTC was attached to student notebooks for their quick reference so that students were actively involved in the tracking of their own progress. The notebooks were used to track student learning over the course of the treatment. These notebooks were used extensively by the students to draft comments and create illustrations about their learning and conceptual understanding of the solar system concepts.

Students filled in a red, yellow, or green light that best matched their thinking in regards to the science concept being taught. Students would show evidence of their learning to me during an informal conference. This evidence was provided in conversation between the student and me in writing or illustration format. From this data, I was able to determine which classroom assessment techniques were enabling my students to express their ideas and conceptual understanding and adjust my teaching strategies to differentiate my instruction.

Probes were introduced to uncover student ideas about the world. I used “Gazing at the Moon” and “Going through a Phase” from *Uncovering Students Ideas in Science* (Keely, Eberly & Farrin, 2005) (Appendix F). The purpose of “Gazing at the Moon” assessment was to elicit students’ ideas about the Earth, Moon, and Sun system. The purpose of using the probe “Going through a phase,” was to elicit students’ ideas about what accounts for the phases of the Moon.

The Getting to the Heart of the Matter (Gregory & Chapman, 2002) was implemented to determine and build background knowledge and synthesize student understanding of a science concept (Appendices G). The “Getting to the Heart of the Matter,” which is an artistic and written representation of ideas, prior knowledge, questions, and beliefs, was completed by small groups of students. The focus of this formative assessment was to uncover beliefs that may hinder or consequently strengthen further learning. Checks can assist in uncovering traditional beliefs and different worldviews held by students. The Getting to the Heart of the Matter was used to promote team building, class discussion, cooperative learning, and the use of higher order thinking (Bloom, 1956) prior to instruction of two solar system lessons. I monitored students asking probing questions to promote group discussion and team building. Students shared-out results to other groups.

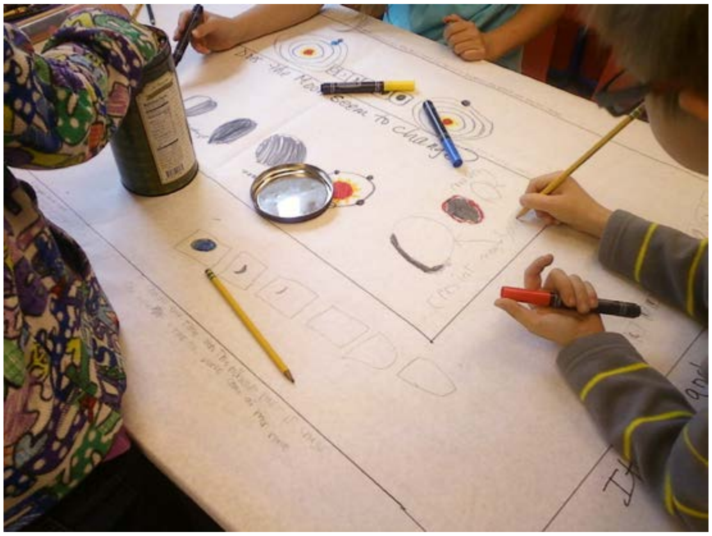


Figure 1. Getting to the Heart of the Matter, (*N*=15).

Classroom assessment techniques (CATs) included the "The Muddiest Point." This CAT was posted at the end of each lesson for students to self-assess their understanding of the current topic (Appendix H). Students wrote down a quick response to one question: "What was the muddiest point in ____?" The focus of this assessment was on the lesson for that day. Responses were reviewed quickly and discussed before the ending of the lesson to clear up any misconceptions.

Throughout the study, I made anecdotal observations and took notes regarding student motivation, application and engagement during our school day. These observations were noted to encourage discussion between peers and myself (Appendix I). They helped guide our next steps in the learning process. Surveys, interviews and classroom assessment techniques were used to determine the effects on students' conceptual understanding.

The data collected from this study were both qualitative and quantitative in nature. Because of this, several different methods of data collection were utilized to evaluate the effectiveness of the formative assessments presented to increase student conceptual understanding. Qualitative data collection techniques were evaluated to determine overall trends and patterns, within and across the spectrum. Quantitative data collection techniques were used to gather information about student learning that was analyzed and interpreted using descriptive statistical techniques in excel, such as mean, and net gain.

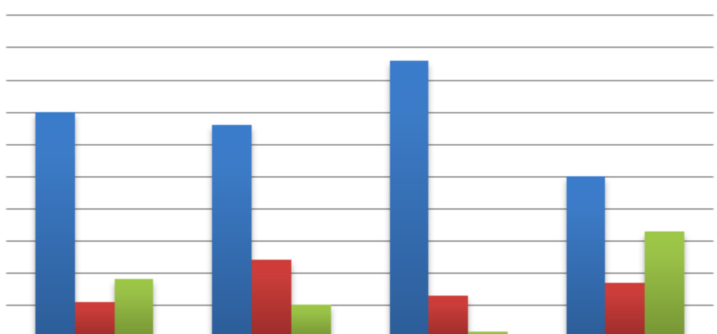
Using a combination of qualitative and quantitative data provided an accurate representation of the effects of the use of formative assessment interventions in the second grade science class (Table 1).

Table 1
Data Triangulation Matrix

Focus Questions	Data Source 1	Data Source 2	Data Source 3
Primary Question:			
1. What *impact* does the use of formative assessments have on student achievement in science?	TOSRA	Smiley Face Survey	Student science achievement assessment scores
Secondary Question:			
2. What *affect* does the use of formative assessments have on my overall instructional practices to inform my teaching?	CAT's-Muddiest Point Classroom Assessment Techniques: A Handbook for College Teachers Angelo and Cross (1993)	Gazing at the Moon Going through a phase Uncovering Student Ideas in Science, Vol. 1: 25 Formative Assessment Probes Keeley, et al., (2005)	Curriculum based assessments such as teacher made tests, interviews, surveys, anecdotal notes and projects.

DATA AND ANALYSIS

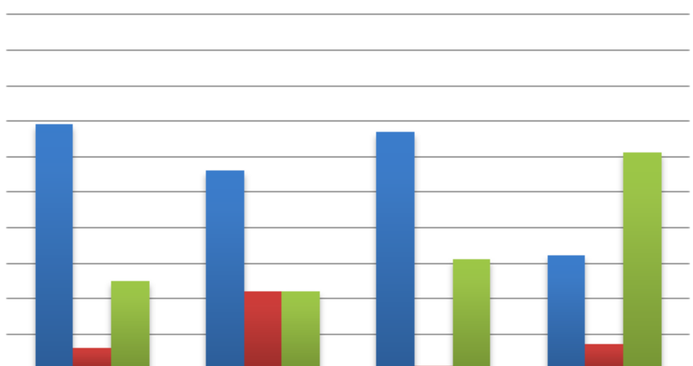
The four attitude scales I used were an effective way to explore baseline information that was helpful in determining student's overall attitude toward science before and after my action research. The results of the TOSRA Pre-Assessment indicated that 70% of the students had a positive attitude toward science inquiry and 66% positively enjoyed science lessons (*N*=15). One student said, "Science is my favorite time of day." Fifty percent of my students indicated they would like a career in science with 33% stating they would not like to work in a science related field. Eighty-six percent of the students have a strong interest in leisure science, with only 2% of the students responding that they do not have an interest in leisure science.



	Attitude in Science Inquiry	Enjoyment of Science Lessons	Leisure Interest in Science	Career Interest in Science
Positive responses	70%	66%	86%	50%
Neutral responses	11%	24%	13%	17%
Negative responses	18%	10%	2%	33%

Figure 2. Test of Science-Related Attitudes (TOSRA) Pre Treatment Student Survey, (*N*=15).

During the action research time frame, I had two new students enroll in our classroom, increasing the sample size to 17. The results of the Post-TOSRA Assessment indicated that 69% of the students maintained a positive attitude toward science inquiry and 56% positively enjoyed science lessons. Two students commented, “I didn’t know that I liked science so much!” Thirty-two percent of my students indicated they would like a career in science with 61% stating they would not like to work in a science related field. Sixty-seven percent of the students have a strong interest in leisure science, with 31% of the students responding that do not have an interest in leisure science. The figure below illustrates the results of the post TOSRA (Figure 3).



	Attitudes in Science	Enjoyment in science	Leisure Science	Career in Science
Positive Responses	69%	56%	67%	32%
Neutral Responses	6%	22%	1%	7%
Negative Responses	25%	22%	31%	61%

Figure 3. Test of Science-Related Attitudes (TOSRA) Post Treatment Student Survey, (*N*=17).

The results of the pre Attitudes in Science Survey scale of the TOSRA indicated that 66% of students responded with *strongly agree* and 17% responded *strongly disagree*. Fifty-three percent responded with *strongly agree* when asked if they enjoyed a science lesson, as compared to 10% who *strongly disagreed*. The data also depict 24% of students responding with a *neutral* reply.

The results of the post Attitudes in Science scale indicated that 65% of students responded with *strongly agree* and 24% responded *strongly disagree*. Eighty-two percent reported that they *strongly agree* when asked if they enjoyed a science lesson, as compared to less than 1% who *strongly disagreed*. The data also depict 18% of students responding with a *neutral* reply. Students responded with comments such as, “It depends upon what we are studying if I like it or not.” One student replied, “I like science lessons when we get to go outside and work with a partner.”

The pre Leisure Interest in Science scale of the TOSRA indicated that 86% of students responded with *strongly agree* and 0% responded *strongly disagree*. Thirteen percent reported with a *neutral* response and 2% reported *disagree*. The pre Career in Science scale of the TOSRA indicated that 41% *strongly agree* and 30% reported *strongly disagree*. One student asked, “Is there a kind of scientist that gets to work outside?”

The results of the post Leisure Interest in Science scale indicated that 63% of students responded with *strongly agree,* and 28% responded *strongly disagree*. One percent reported with a *neutral* response and 4% reported *disagree*. The post Career in Science Post scale indicated that 28% *strongly agree* and 56% reported *strongly disagree*. One student remarked, “I thought I wanted to be a scientist, but now I don’t know.”

The TOSRA survey effectively summarized all survey attitudes and generated substantial pretreatment information (15 surveys with 300 responses) and post treatment information (17 surveys with 340 responses.) Based upon the data from the participants in my study, I found an increase in positive attitudes for science from the pre to post survey. It is notable that overall my findings are that my students have a greater than 2 to 1 ratio of *agreeable* to *disagreeable*.

All areas showed a positive increase except for the “Career in Science” item. This item indicated that in the pre-survey 33% *strongly disagreed* and in the post-survey 61% chose *strongly disagree*. This item is a 2 to 1 preference for *disagreement* than *agreement.*

The results of the pre-interviews given to students to determine learning style preferences indicated that 61% of students liked to work in pairs, while only 33% of students liked to work directly with the teacher. Post-interview results suggested an increase in the number of students to 71% who liked to work in pairs and a decrease in the number of students to 29% who liked to work directly with the teacher. Students that liked to work in small groups were 33% prior to instruction and 18% post instruction. Whole group instruction was the least chosen learning setting, at 6% pre-treatment and 0% post-treatment.

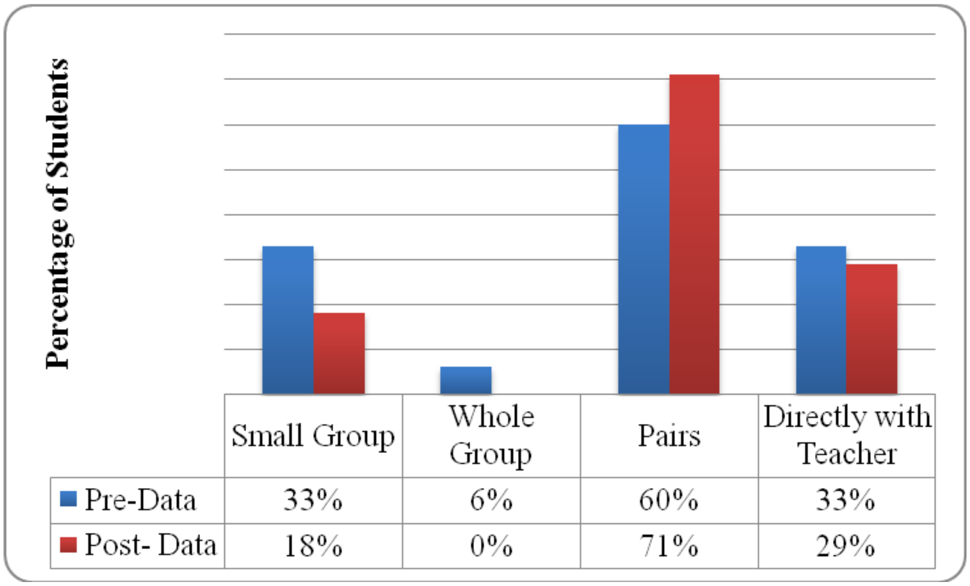


Figure 4. Preferred Learning Styles-Before and After Treatment, Pre (*N*=15), Post (*N*=17).

Student data gathered from the “Traffic Light Survey” indicated increased student ownership of tracking their progress of science content over time throughout the unit of study. Sixty-three percent of students were more willing to ask questions and research answers to their questions on their own as opposed to only 42% at the beginning of the research. Student conceptual knowledge on “The Solar System” unit was 66% as compared to the “Weather Unit” at 50% concept knowledge. This was determined by students explaining their thinking through the “Traffic Light Tracking Progress Chart” on the required science concepts provided for the unit of study, assignments and chapter tests.

Student data resulting from the “Smiley Face Attitude Survey” affirm the positive results from the TOSRA data and pre-post interviews. For example, students responded in the pre-assessment regarding having learning targets posted with 21% choosing a *frowny face*, and 50% a *smiley face*. After the treatment, students reported 12% *frowny face* and 63% *smiley face*, for having the learning target posted. Students responded in the pre-assessment regarding being able to explain or show evidence of their conceptual knowledge with 36% a *smiley face,* and 70% a *frowny face.* After the treatment, students responded with 73% a *smiley face,* and 27% a *frowny face.* One student stated, “I like being able to show my evidence for science concepts by explaining in my own words and drawings.” Students indicated an increase in positive attitudes towards the format of the lessons and the outcomes of their learning.

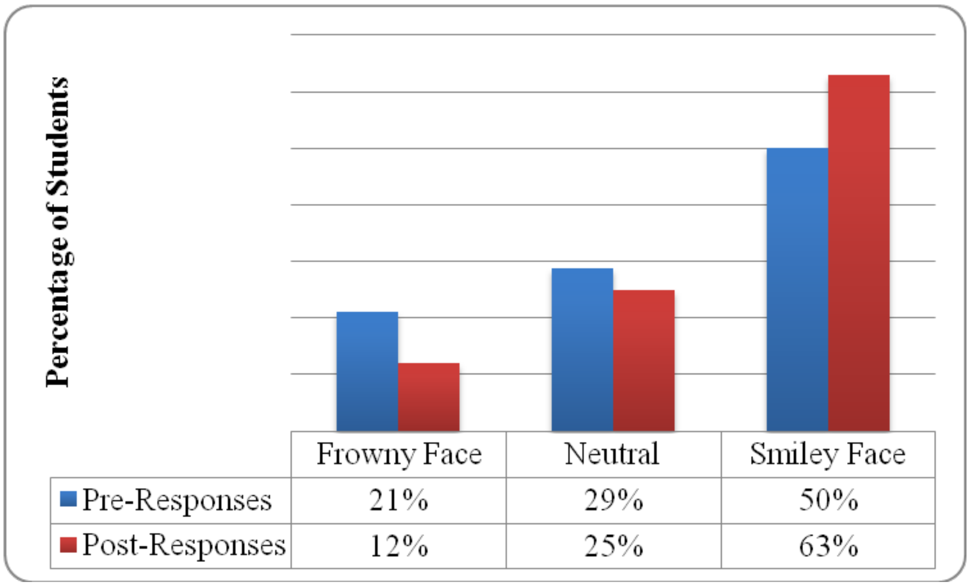
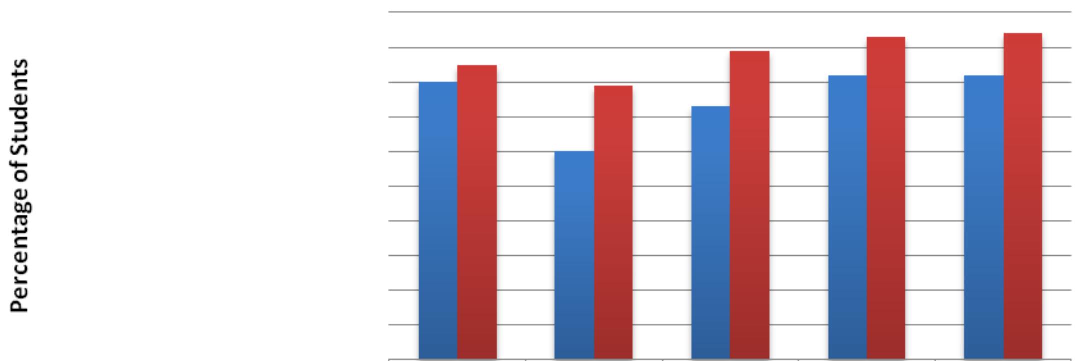


Figure 5. Smiley Face Student Attitude Surveys-Before and After Treatment, Pre (*N*=15), Post (*N*=17).

The change in treatment from the “Weather” unit to the “Solar System” unit involved incorporating formative assessments and active student involvement in their learning. Students were given the opportunity to demonstrate their knowledge using different formats for the formative and summative assessments. I was able to develop multiple ways of teaching each lesson topic to differentiate and include additional interactive instructional methods and assessment techniques. Student scores increased on every lesson as well as on the chapter test and on the overall average of scores. Overall assignment averages for the Solar System unit increased over those for the pretreatment Weather unit (Figure 6).



	Lesson 1	Lesson 2	Lesson 3	Lesson 4	Chapter Test
Weather Unit Assignments/Chapter Test	80%	60%	73%	82%	82%
Solar System Unit Assignments/Chapter test	85%	79%	89%	93%	94%

Figure 6. Assignments and Cumulative Test/Project-Before and After Treatment, Pre (*N*=15), Post (*N*=17).

Student data resulting from the "Going Through a Phase Probe" generated students' ideas about their observations of the moon phases. Zero percent of my students were able to explain the role of light reflection and the relationship that the Earth, Moon and Sun have together in the pre-assessment. However, by the end of the "Solar System" unit, 55% of the students were able to identify the phases through observation, drawing and manipulating moon phase cards. Eighty percent were able to show evidence that there is a consistent pattern occurring each month. The "Gazing at the Moon Probe" affirmed the conclusions of the previous probe in which students were able to give their perception of the Earth, Moon and Sun system. The uses of these probes were useful in determining ideas that were taught and learned at home within other cultures. It also acknowledged that students at this developmental stage are not at the level of understanding the causes of the phases of the moon (Keeley, 2005).

The results of the “Getting to the Heart of the Matter” assessment sustain the positive results of the Smiley Face Survey, interviews and the Traffic Light Tracking Progress Survey. The Getting to the Heart of the Matter resulted in all students contributing to the understanding of science concepts. There was a synergy relationship between the students and me during this activity. This assessment encouraged peers to collaborate and flush out science ideas and beliefs. Each small group of students was able to develop and represent the science concepts learned over the course of the treatment.

The Muddiest Point classroom assessment technique continued the positive attitudes of students during the treatment period. At the beginning of the “Solar System” unit, students were reluctant to write a “muddiest point.” Data shows 25% of students asking a question concerning the science topic. At the end of the treatment period, 82% of students were asking probing questions about the current science topic.

INTERPRETATION AND CONCLUSION

The primary focus question for my capstone study queried the impacts of using regular formative assessment on students’ conceptual understanding in science. Results of the study provide evidence that this practice improves student achievement in science as indicated by higher post treatment assignment scores and unit tests. Students who are given the opportunity to provide evidence of their learning through a variety of means, with the use of formative assessment, such as projects, drawings, models and verbal explanation have revealed through this treatment to be more likely to have a positive attitude towards science.

This study provided evidence that differentiating instruction to match the student's learning styles increased student success academically as shown with their assignment and test scores. Students had an increase in positive attitudinal responses in the post-TOSRA test when students were able to learn in cooperative groupings that were most comfortable to them. The data supports that students enjoyed working in small groups and pairs over whole group instruction. By using assessments in a formative manner, whether they are interviews, projects, and flexible groupings, can be a factor in positive individual and classroom learning experiences.

The increase in positive student responses given for the use of Classroom Assessment Technique activities surveyed in the Smiley Face Attitude Survey and the results of the TOSRA attitudes survey has persuaded me to incorporate classroom assessment techniques into other subject areas, such as math. Students now ask to use different classroom assessment techniques to monitor their learning and express their thinking. Many students take out the red/green cards and our muddiest point laminated sheets and place them on their desks prior to science and math instruction. Posting the learning target on the board and reading it together for understanding of the lesson's objective also increased in popularity after the implementation of the treatment. Students began to take the initiative to write the learning target on the board, thus taking ownership for their learning.

The improved scores have influenced how I oversee my instructional practice. I am now giving students a choice on how they would like to show evidence of their learning. I always begin lessons by jointly writing clear learning targets together and establishing the purpose of each science concept. Building background knowledge together and pooling our understanding of a topic is primary so students will take an active part in their learning.

This action research project provides evidence that the implementation of teaching strategies that include formative assessments increases students' conceptual understanding of science concepts. Classroom practices that make the most of student successes often include quality teacher strategies such as setting a clear purpose, writing concise learning targets, sound lesson design, effective communication and student involvement between the teacher and the students (Chappuis, 2009). The use of formative assessments has increased in frequency in my classroom practice. As a result, I am now setting learning targets for myself to monitor and track my progress. For example, I now record evidence of my teaching practices, which informs my teaching decisions.

VALUE

The inclusive understanding of constructing and completing this capstone project has led to many significant changes in how I now approach teaching and learning in my classroom. First, I can use classroom assessment processes and results formatively to increase student conceptual understanding. This not only includes the classroom assessment techniques but also engaging my students to actively participate in the learning process.

For my students, the study results suggest that utilizing multiple formative techniques and strategies increases students' success in science. They experienced higher assessment scores and showed evidence that they found their voice in the learning process. They are more likely to express their confusions, questions, and "ah-ha moments." One student said, "I really like being able to draw my thinking, it makes it clearer in my head." Another stated, "I like using the "Muddiest Point Sheet," because it is fast and easy to tell one thing or ask one question." Students spent quality time with their illustrations and comments when I gave them uninterrupted working time and media to use.

Secondly, I have developed strategies to set clear purposes before beginning a new unit of study. This has enabled me to better understand how my students learn best. Encompassing all the resources prior to teaching, writing clear, student friendly objectives, and letting go of my control over my students in our classroom has made a tremendous positive impact upon our classroom environment. I believe one of the hardest things I have had to overcome is letting my students fail to succeed. I was too quick to jump in and assist. Now I am using "wait-time" more effectively.

This experience has been valuable in pointing out that we are all learners, especially the teacher. The positive growth that has occurred over the course of this experience has come in ebbs and waves. There were times when I was assessing the students too much, and it showed in their demeanor. I learned to pull back and be a silent observer. Being able to ask the right questions of myself is as equally important as asking the right probing questions of my students. I gained valuable content and cultural knowledge from my students during this research time. I *learned* from my students.

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APPENDICES

APPENDIX A

INDICATORS OF SOUND CLASSROOM ASSESSMENT PRACTICE

Indicators of Sound Classroom Assessment Practice

Keys to Assessment Quality and Teacher Competencies

Keys to Quality	**Teacher Competencies**
1. Clear Purposes Assessment processes and results serve clear and appropriate purposes	a. Teachers understand who the users and uses of classroom assessment information are and know their information needs. b. Teachers understand the relationship between assessment and student motivation and craft assessment experiences to maximize motivation. c. Teachers use classroom assessment processes and results formatively (assessment *for* learning). d. Teachers use classroom assessment results summatively (assessment *of* learning) to inform someone beyond the classroom about students' achievement as of a particular point in time. e. Teachers have a comprehensive plan over time for integrating assessment *for* and *of* learning in the classroom.
2. Clear Targets Assessments reflect clear and valued student learning targets	a. Teachers have clear learning targets for students; they know how to turn broad statements of content standards into classroom-level targets. b. Teachers understand the various types of learning targets they hold for students. c. Teachers select learning targets focused on the most important things students need to know and be able to do. d. Teachers have a comprehensive plan over time for assessing learning targets.
3. Sound Design Learning targets are translated into assessments that yield accurate results	a. Teachers understand what the various assessment methods are. b. Teachers choose assessment methods that match intended learning targets. c. Teachers design assessments that serve intended purposes. d. Teachers sample learning appropriately in their assessments. e. Teachers write assessment questions of all

	types well. f. Teachers avoid sources of mismeasurement that bias results.
4. Effective Communication Assessment results are managed well and communicated effectively	a. Teachers record assessment information accurately, keep it confidential, and appropriately combine and summarize it for reporting (including grades). Such summary accurately reflects current level of student learning. b. Teachers select the best reporting option (grades, narratives, portfolios, conferences) for each context (learning targets and users). c. Teachers interpret and use standardized test results correctly. d. Teachers effectively communicate assessment results to students. e. Teachers effectively communicate assessment results to a variety of audiences outside the classroom, including parents, colleagues, and other stakeholders.
5. Student Involvement Students are involved in their own assessment	a. Teachers make learning targets clear to students. b. Teachers involve students in assessing, tracking, and setting goals for their own learning. c. Teachers involve students in communicating about their own learning.

Table 1.2, "Indicators of Sound Classroom Assessment Practice," comes from *Classroom Assessment* for *Student Learning: Doing It Right—Using It Well,* page 27.© 2009 ETS Assessment Training Institute, Portland, OR www.ets.org/ati 800.480.3060

APPENDIX B

TEST OF SCIENCE-RELATED ATTITUDES

NAME:__________________________________

Participation in this research is voluntary and participation or non-participation will not affect a student's grades or class standing in any way.

Test of Science Related Attitudes (TOSRA)

(Fraser, 1981)

Directions:

1. This test contains a number of statements about science. You will be asked what you think about these statements. There are no "right" or "wrong" answers. Your opinion is what is wanted.
2. For each statement, draw a circle around the specific numeric value corresponding to how you feel about each statement. **Please circle only ONE value per statement.**
3. For positive items, response SA,A,N,D, SD are scored 5,4,3,2,1 respectively. Omitted or invalid responses are scored a 3.

5 = Strongly Agree (SA) 4 = Agree (A)

3 = Uncertain (U) 2 = Disagree (D) 1 = Strongly Disagree (SD)

Statement	**SA**	**A**	**U**	**D**	**SD**
1. I would prefer to find out why something happens by doing an experiment than by being told.	5	4	3	2	1
2. Science lessons are fun.	5	4	3	2	1
3. I would like to belong to a science club.	5	4	3	2	1
4. When I leave school, I would like to work with people who make discoveries in science.	5	4	3	2	1
5. I would prefer to do experiments rather than to read about them.	5	4	3	2	1
6. School should have more science lessons each week.	5	4	3	2	1
7. I would like to be given a science book or a piece of science equipment as a present.	5	4	3	2	1

Statement	SA	A	U	D	SD
8. Working in a science laboratory would be interesting.	5	4	3	2	1
9. I would prefer to do my own experiments than to find out information from a teacher.	5	4	3	2	1
10. Science is one of the most interesting school subjects.	5	4	3	2	1
11. I would like to do science experiments at home.	5	4	3	2	1
12. I would like to teach science when I leave school.	5	4	3	2	1
13. I would rather solve a problem by doing an experiment than be told the answer.	5	4	3	2	1
14. I really enjoy going to science lessons.	5	4	3	2	1
15. A job as a scientist would be interesting.	5	4	3	2	1
16. I would prefer to do an experiment on a topic than to read about it in science magazines.	5	4	3	2	1
17. I look forward to science lessons.	5	4	3	2	1
18. I would enjoy visiting a science museum on the weekend.	5	4	3	2	1
19. I would like to be a scientist when I leave school.	5	4	3	2	1
20. If you met a scientist, he/she would probably look like anyone else you might meet.	5	4	3	2	1

APPENDIX C

INTERVIEW QUESTIONS

Interview questions

Participation in this research is voluntary and participation or non-participation will not affect a student's grades or class standing in any way.

1. How do you like to learn? Do you like working independently, small/whole group, with the teacher or in pairs? Why or why not?
2. Do you like to build projects to explain your understanding of the science concept(s)?
3. Do you like to draw/illustrate/label your understandings of science concepts?
4. Is there anything else you would like me to know?

APPENDIX D

SMILEY FACE STUDENT ATTITUDES SURVEY

Smiley Face Student Attitudes Survey

Participation in this research is voluntary and participation or non-participation will not affect a student’s grades or class standing in any way. Please respond to the following by using a check-mark in the column that mostly matches your opinion.

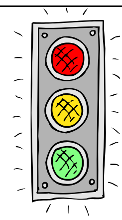
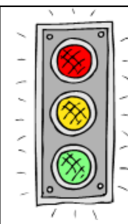
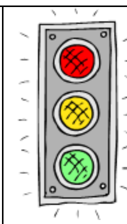
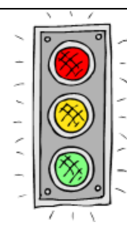
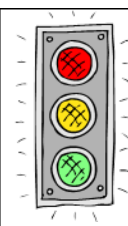
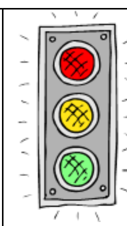
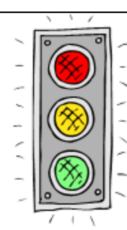
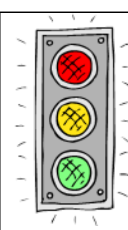
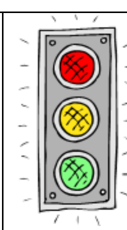
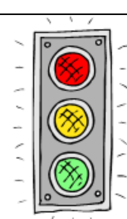
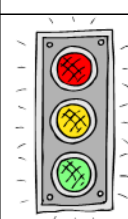
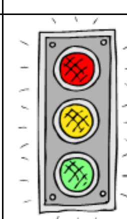
Statements			
I like having the learning target posted on the front white board.			
Did this lesson uncover any miss or pre conceptions you had in regards to…?			
Did this lesson enable you to learn the concept of …?			
Were you able to explain your understanding of the science concept(s) or show evidence?			
Did you like the assessment(s) used?			
Were you able to work in your group/or independent setting?			
Is there anything else you’d like for me to know?			

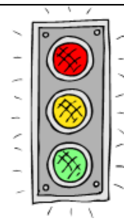
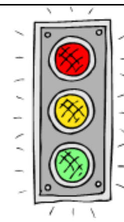
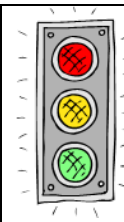
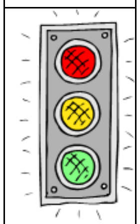
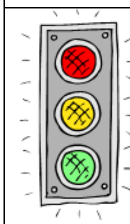
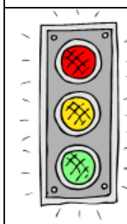
APPENDIX E

STUDENT TRAFFIC LIGHT TRACKING CHART

Student Traffic Light Tracking Progress

Participation in this research is voluntary and participation or non-participation will not affect a student's grades or class standing in any way.

Learning Targets	Date Evidence	Rating	Date Evidence	Rating	Date Evidence	Rating
Lesson 1						
I can explain that stars and planets are always in the sky.						
Lesson 2						
I can describe/model how the Earth's rotation causes night and day.						
Lesson 3						
I can describe/model how the moon orbits the Earth.						
I can describe how light reflected by the moon looks different every day.						

Lesson 4						
I can identify the causes of the seasons.						
I can describe changes that occur during seasons.						

 Solar System Unit	Goal setting Something I already do well: Something I still need to work on:

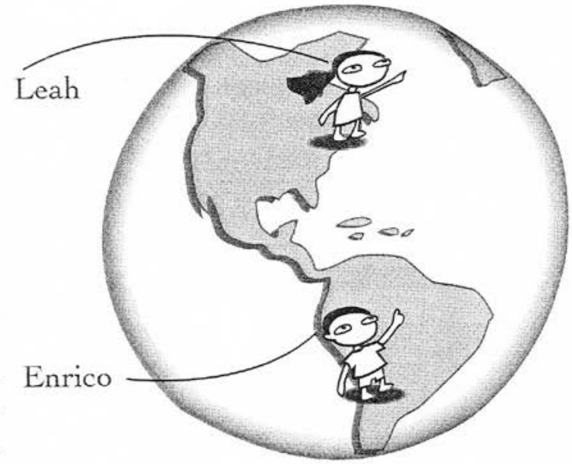
APPENDIX F

STUDENT PROBES

Participation in this research is voluntary and participation or non-participation will not affect a student's grades or class standing in any way.

Gazing at the Moon

Enrico and Leah live in opposite hemispheres. Enrico lives in Santiago, Chile, which is in the Southern Hemisphere. Leah lives in Boston, Massachusetts, which is in the Northern Hemisphere. They both gazed at the Moon on the same evening. Enrico noticed there was a full Moon when he looked up at the sky from his location (the Southern Hemisphere). What do you predict Leah saw when she looked up in the sky from her location (the Northern Hemisphere)?



A New Moon (no part of the Moon is visible)

B Crescent Moon (a quarter of the face of the Moon is visible)

C Half Moon (half of the face of the Moon is visible)

D Gibbous Moon (three-quarters of the face of the Moon is visible)

E Full Moon (the entire face of the Moon is visible)

Provide an explanation for your answer. How did you decide what the Moon would look like in the opposite hemisphere?

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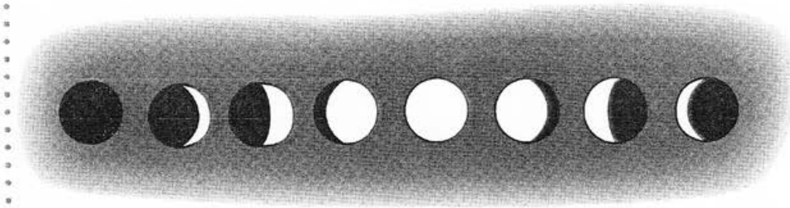
Uncovering Student Ideas in Science 177

Going Through a Phase



Mrs. Timmons asked her class to share their ideas about what causes the different phases of the Moon. This is what some of her students said:

Mona: The Moon lights up in different parts at different times of the month.

Jared: The phases of the Moon change according to the season of the year.

Sofia: Parts of the Moon reflect light depending on the position of the Earth in relation to the Sun and Moon.

Drew: The Earth casts a shadow that causes a monthly pattern in how much of the Moon we can see from Earth.

Trey: Different planets cast a shadow on the Moon as they revolve around the Sun.

Oofra: The shadow of the Sun blocks part of the Moon each night causing a pattern of different Moon phases.

Natasha: The clouds cover the parts of the Moon that we can't see.

Raj: The Moon grows a little bit bigger each day until it is full and then it gets smaller again. It repeats this cycle every month.

Which student do you agree with and why? Explain your thinking.

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APPENDIX G

GETTING TO THE HEART OF THE MATTER

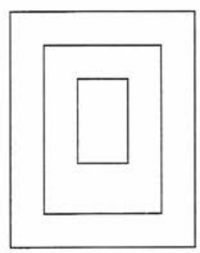
Boxing: Getting to the Heart of the Matter

Purpose: This strategy will help students build background knowledge and synthesize their understanding of a topic. The posters can be shared gallery style or presented orally and will provide useful assessment information.

Materials: Poster paper, markers, and copies of the text(s) for each member of the group.

Procedure:

- Divide class into groups of 4
- Each member needs a different color marker with which to write in the frames. This offers a visual assessment of developing understanding for both the student and teacher.
- Draw a box to create a fairly wide frame for the poster.
- Draw a smaller box inside the first.
- The boxes will create 3 spaces for representing learning.
- In the outer frame, the group writes their prior knowledge about or possibly what they want to learn about the topic. They may have been given a photo, quote, or short reading to activate this knowledge.
- Next read to build background knowledge about the topic. The members could read the same text or a variety of texts (e.g. primary source documents, news articles, maps, timelines, photos) could be jigsawed.
- Share and discuss, then write about new insights inside the inner frame.
- Finally, in the middle box, either write a summary of the learning or create a graphic illustration or visual metaphor that synthesizes the group's understanding of the topic.



paragon education network

Adapted from *Differentiated Instructional Strategies: One Size Doesn't Fit All.* G. Gregory and C. Chapman, Corwin Press, 2002.

Participation in this research is voluntary and participation or non-participation will not affect a student's grades or class standing in any way.

APPENDIX H

MUDDIEST POINT

Muddiest Point

Participation in this research is voluntary and participation or non-participation will not affect a student's grades or class standing in any way.

Do you have a muddiest point for the teacher?

APPENDIX I

STUDENT ANECDOTAL STUDENT FORM

Student Anecdotal Record Form

Name: ___________________________

Date: _______Comments:

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Date: _______Comments:

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Date: _______Comments:

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