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Formative Assessment as a Method to Improve Student Performance in the Sciences

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Abstract: This study focused on utilizing formative assessment to shape student understanding and teaching practices in a junior high science classroom. Students were given a pre-test as a method of formative assessment and their results on the pre-assessment before instruction were compared to their performance on a modified post-test. Students received direct instruction, completed an independent project, and responded to daily “bellringer” questions as a form of additional formative assessment before taking the post-test. Students showed marked improvement on the post-test as average scores increased from a 35.7 percent to a 94.4 percent.

Introduction

Current educational policy in the state of Ohio involves a series of standardized tests that students in every district must take in specified grade levels, and the reported results are used to “grade” school and district-level achievements, and may be used to make funding adjustments. Preparation for these exams is crucial to any classroom teacher, as these summative assessments are important for the district, state, and nation. For science subjects, there are two required statewide exams in grade five and grade eight, along with the required high school exam. Year-long test preparation is the reality of many teachers, and there are many methods to provide quality instruction, even when the end goal may be the passing of a state-required exam. One strategy that can improve instruction effectiveness, student understanding, and student learning is utilizing formative assessments. These are assessments given during the time when content is presented, and can be realized in many ways: understanding probes, pre- and post-assessments, unit-long extended projects, discussion groups, and more. These “assessments” can be given to gauge student understanding of new material, student self-efficacy, student background knowledge, and effectiveness of teaching methods in achieving learning objectives.

In the sciences, where understanding of processes like the scientific method is as crucial as pure content understanding, summative assessment does not provide a complete picture of true student understanding. I want to use this project to better understand the potential impacts of formative assessment on summative assessment performance, by better understanding the foundations of formative assessment theory, and how formative assessment may allow teachers to tailor instruction to student needs. For the duration of this action research study, I want to utilize formative assessments to better understand how students in a general science course process information, build understandings, and retain “big picture” concepts.

Literature Review

The concept of ‘formative assessment’ has been discussed by many scholars, and formative assessment may look different in each classroom utilizing it. There are universal understandings relating to what formative assessment is and is not, and these are represented as a unifying theory of formative assessments. Formative assessment is the process of evaluating student understanding throughout the duration of a unit to better inform teacher practice and instructional strategies. Formative assessment is not used to assign a formal grade, rather, it is used as a building block for effective instruction, founded in exploring student understanding. Formative assessment theory has been described and expanded upon by many authors in a variety of contexts. According to Ninomina (2016), formative assessment “aims to improve teaching and learning by focusing on the learning process, particularly on the dialogue between the teacher and student”. This description is in line with a variety of other authors: Spector et al. (2016), where “emphasis is on forming judgments about learners’ progress that then affects the subsequent flow of instruction...”; Cohen and Sasson (2016), where “The goal of formative assessment is to gather feedback... to guide improvements in ongoing teaching and learning...”; Jacoby et al. (2014) state “Not all assessment needs to contribute to the final summative grade but they can be used for self-assessment formatively whereby students can determine their own progress...”; and Clinchot et al. (2017) state that “Formative assessment helps teachers identify strengths and weaknesses in their students’ understanding, [and] focuses students’ attention...”. From these many authors, it is clear the core of formative assessment is the students, where the teacher must identify and be responsive to the needs of students and adapt teaching styles accordingly. These statements place formative assessment clearly apart from summative

assessment, which functions to provide a “grade” based on content understanding, rather than a method to form future instruction.

Though many authors have provided an explanation of what formative assessment theory is, building lessons requires a more practical definition. Black and Wiliam (2009) provide five key tenants for formative assessment. The first key is related to the clarity of purpose and goals that the instructor must provide. Students need to be fully aware of what “success” means for the lesson, the unit, and the course. Teachers can provide clarity of expectations via daily guiding questions, collecting exit slips, or providing a pre-test before units. The second key is that any learning tasks must provide clear evidence of student understanding. The student understanding could be evident in formative assessment performance and classroom discussions, both peer-to-peer and student-to-teacher. The third key is that instructors must provide effective, helpful, and relevant feedback to learners. This feedback should be provided as quickly as possible after the learning task is completed. For formative assessment, the feedback should ideally be provided at the start of the next class period. This contrasts final exams or other forms of summative assessment, where evaluation can take more time. The fourth key states that formative assessment should bring students to understand they can and should utilize the knowledge of their peers to guide their own understandings. This can be emphasized in classrooms with the rule that students must ask three of their peers for help before they can ask the teacher. The fifth key is formative assessments are “activating students as owners of their own learning” (Black and Wiliam, 2009). These “keys” provide the basis of formative assessment theory, where students are given fair evaluations that reflect previously-established goals where the results are not always used to assign a grade, but are used to build future instruction and encourage students to pursue diverse methods of thinking and problem-solving.

The existing literature describing formative assessment frequently refers to the possibility of improving student self-motivation, self-efficacy, and metacognition. Clark (2012) specifies many self-regulating habits that can be formed and encouraged via formative assessment, including “personal goal-planning, monitoring, and reflection”. These behaviors are translated into intrinsic motivation for learning, and are important skills to encourage in classrooms using more student-centered practices. There is support for the notion that formative assessment does more than allow teachers to monitor student progress, as Weurlander et al. (2012) states “Our findings show that formative assessments are an important tool for students’ learning in... motivation to study, [and] awareness of their own learning and the effects on learning, in terms of both processes and outcomes...” For example, providing students with a clear outline of expected skills and understandings can help them filter out less relevant information and motivate their studying practices to focus on crucial content and enduring understandings. While teachers may feel that all the content they present is crucial for students to retain, it can be overwhelming at best and impossible at worst. Formative assessment allows students and teacher to recognize what the “big picture” of a unit should be. Formative assessment functions beyond an evaluation of content understanding, involving student motivation and self-efficacy.

The practices of student self-regulation include regulation in a variety of sectors. These include regulation of cognitive and metacognitive thoughts, where students are ‘thinking about thinking’, including their problem-solving strategies and how best to apply background knowledge. Another aspect of self-regulation can include the way students participate in class discussion, group activities, etc. For example, one student may choose to actively take notes as discussion is happening, while another may choose only to listen, and a third may try to participate at every available opportunity with a thought of their own. All these strategies are

valid, based on a student's preferred learning style (visual, auditory, or kinesthetic). A third aspect of self-regulation can involve motivation, for example, if students self-motivate by rewarding themselves for completing a certain task with a ten-minute break, or if a student wants to understand a more advanced concept, like quantum mechanics, so they pay close attention to classroom readings about physics. Another dimension that students can self-regulate is the learning environment, which can include how the student chooses to interact with peers and ask for help (Clark, 2012). Self-regulation of the learning environment may include how the student chooses to complete homework, if they have a dedicated space like a desk, or if they are content to sit on the floor in front of the TV to complete work. Though one of these strategies may seem "better" than the other, the student will eventually learn which environment provides them with continued success, and can adjust their behavior accordingly.

There is an importance to students recognizing how they think, self-motivate, and problem-solve, as these behaviors will encourage future success in all grade levels and at the college level. Black and Wiliam (2009) emphasize that formative assessment teaches meta-cognitive behaviors, stating, "By challenging learners to reflect on their own thinking, teachers and their peers help them to make unconscious processes overt and explicit...". Formative assessment provides students with the opportunity to be reflective learners as they practice self-regulation and metacognition. The behaviors supported by formative assessment provide students with a foundation for how they learn, and the skills they develop regarding self-motivation will continue throughout their educational and professional careers.

For students to build understanding based on formative assessments, a crucial aspect teacher and/or peers must provide is feedback. Feedback can come in many different forms, and can include an actual point or letter grade, short conferences to gauge student progress and

provide guidance, or peer discussion and peer evaluation (Spector et al. 2016). Another common form of feedback is written feedback from the teacher on assignments, highlighting successes and areas of concern. Clark (2012) states that feedback should provide the student with a degree of confidence, especially when it comes to problem-solving abilities. This confidence should come from the teacher functioning as a coach, rather than a place for stored knowledge, as the teacher directs the students to reflect on feedback and improve. Regardless of how feedback is provided to students, teachers should have a method of tracking student development, in terms of content understanding, social skills, and practical skills. Coffey et al. (2011) also support this point when they state that teacher feedback is crucial for developing understandings of student learning, by both the student and the teacher.

Feedback, however, is inherently complex, and student responses to feedback may be influenced by a multitude of factors. As Nicol and McFarlane-Dick (2006) explain, “feedback both regulates and is regulated by motivational beliefs”, so students’ behavior can be influenced by teacher feedback based on how it is interpreted and valued. If a student perceives feedback as completely negative, it may promote thoughts of failure and detract from a student’s motivation. If feedback is constructive and relevant, however, it may drive students to make positive changes to how they approach learning. There are unifying ideas of good feedback practices, that positively motivate students and allow development of intrinsic student motivation rather than tying student motivation to extrinsic rewards and punishments as outlined by the teacher. These feedback practices consist of: clarity of evaluation procedures, relevant and quality information related to student performance, open and constructive discussion between peers, flexibility that allows the student to plan how to meet expectations in the future by using a rough draft to final draft system based on instructor feedback, and encouragement of metacognitive behaviors in

students (Nicol and McFarlane-Dick, 2006). Feedback practices have a large impact on the effectiveness of formative assessment, as they can encourage students to explore their own understanding, bring student attention to content mastery expectations, and positively motivate students.

Formative assessments can be utilized as “assessment for learning” or “assessment as learning”, with important distinctions between the two. Assessment for learning is focused on content and meeting learning targets, the student is evaluated to determine their background understanding and where their progress is in relation to established and clear goals. Assessment for learning allows the teacher to gauge student background knowledge of the content or retention of the content as the unit progresses. This contrasts with assessment as learning, which focuses on student reflection on the process of learning, an attempt to encourage metacognition and self-efficacy. Assessment as learning is more student-centered, where the goal may be to help students explain their reasoning and encourage critical thinking skills (Clark, 2012). Formative assessment can be utilized for a variety of purposes and does not always have to focus strictly on comprehension of content.

The practices of formative assessment, including encouraging student self-motivation, cannot always be presented in the same way for all students. As the demographic groups in the United States continue to shift, and school districts must effectively teach every student, regardless of race, gender, or income level, it is important to look at how to utilize formative assessments to benefit all students and differentiate teaching style. Formative assessment has been proven to reduce student anxiety before summative assessments across demographic groups, and varying delivery of formative and summative assessment affects student performance as well. When presented as a “mixed” model, of questions answered both in-class

and questions for students to answer independently at home, student performance is most helped (Agboola and Hiatt, 2017). This allows diverse groups of students to have teacher feedback as a resource during class time, but also allows them to work independently, and receive feedback the next day. When considering assessment practices, it is necessary to determine where most assessments will be conducted (in-class versus online versus take-home exams).

Assessment practices, both formative and summative, may inadvertently advantage or disadvantage students based on their personal experiences and background. Though assessments are not maliciously constructed to unfairly advantage certain groups, it is crucial to note where internal teacher biases may lay during assessment creation. Additionally, assessments can serve to sort and track students, where they are treated differently and receive different instruction based on assessment performance. “Tracking” has more negative connotations, as it is the practice of separating students into defined groups. “Honors” classes are a form of tracking. This differs from the practice of differentiation, which needs to occur even in “tracked” classes, as not all “Honors” students are alike, and every student has a different learning style and level of background. As McGlynn and Kelly (2017) state, “different student groups should not be receiving more or less work. Rather, they should be doing work that is appropriate for their level of understanding”. The concept of “tracking” is a potential problem in interpreting the results of formative assessment, as instruction cannot be built to provide one group of learners with an advantage over other groups. Problems or lapses in understanding shown in the formative assessment should shape instruction for all students, and no student should feel they are receiving a lesser education than their peers due to assessment performance.

There is also much room for improvement in cultural relevancy of assessments and exams. Boykin (2014) states “Results favoring the performance of White students have been

consistently revealed over the last four decades...”. There is evidence in the literature to support that the achievement and understanding of demographic groups outside of ‘White’ students are equivalent when questions are tailored to reflect the group’s culture and language usage (Boykin 2014). In all assessment types, the diversity of students should be reflected so performance is reflective of knowledge and strengths rather than cultural norms and expectations.

Formative assessment is a versatile tool for educators across grade levels and subject areas. The purpose of formative assessment is to shape future instruction, but it teaches behaviors like metacognition, as it requires students to reflect on their problem-solving process and their foundational understandings. Key to effective formative assessment is helpful, constructive, and prompt feedback. Providing feedback allows students to adjust their behaviors to be more successful, especially on assessments where re-submissions are accepted, while providing educators with a “status of the class” for comprehension and/or skills. In the science classroom, I believe formative assessment can be a transformative tool. In the sciences, there are many skills that should be developed alongside content knowledge, such as methodical problem-solving and reflective thinking, like discussing and analyzing the results of an experiment. To ‘test’ these findings in a practical setting, with the hope that students show performance improvement based on formative assessment practices, students in a seventh-grade science classroom will be given a formative pre-test and at the close of a unit section, will be given a post-test.

Methodology

This research was conducted across a period of two weeks in a seventh-grade general science classroom with four separate groups of students. All these students are part of a similar demographic group, with a majority of students across all groups being white and from an upper middle-class socioeconomic background. Students were given a pre-test that consisted of 14

multiple choice questions with information ranging from global convection cells and wind patterns to local weather forecasting. This pre-test was given as a formative assessment to introduce the students to the content the class would be covering in the upcoming unit. The pre-test was provided to students on paper, they were asked to complete the questions on the paper copy and then transfer their answers onto a Google Form created for the purposes of easily tracking student responses and to utilize an online service called Flubaroo that allows Google Form responses to be graded electronically. This form was provided on the Google Classroom associated with seventh graders across all four science classes. The Form did not repeat the questions, rather, the form had each question titled “Question One Answer”, “Question Two Answer”, etc. and provided students with multiple choice options A, B, C, or D. This format was used to prevent students who had not taken the pre-test from accessing the Form on Google Classroom before their class period and using outside resources to find correct answers. Responses were not taken for a formal grade, as this would damage the pre-test as a true tool of formative assessment. Students were told that the pre-test would not be taken for a formal grade, but their final post-test would be taken for a grade. student responses were tracked on a Google Sheets document which was “graded” using Flubaroo to track which questions students were more comfortable with from previous instruction and which questions covered more novel information. The grading feature of Flubaroo was also used to track overall correctness and to more easily collect quantitative data that could show student improvement.

In addition to the formative assessment of the pre-test, students in seventh grade science complete a daily “bellringer” question at the start of every class. This question is meant to either evaluate student background knowledge of new content, remind students of content covered in the previous day’s instruction, or introduce students to the content they will be covering that day.

The question is answered daily by calling on students who volunteer their responses, and students also record their responses in another Google Form that is just for the daily bellringer. Their verbal responses are evaluated immediately to frame the conversation towards what the students will be learning in class, and the learning objectives related to the question asked are also relayed to students. Their responses on the Google Form can be evaluated at any point the teacher feels to track average understanding of the content presented, or to frame future instruction based on student needs. Students do not have access to their responses once submitted due to the nature of student privacy and the accompanying spreadsheet recording all student responses from seventh grade science. Students completed a bellringer question as a formative assessment daily between the date of the pre-test and the date of the post-test.

The instruction provided to students during the two-week period between the pre-test and the post-test involved one full class period of direct instruction through guided notes, one project/activity where students were given a rubric and tasked with re-creating a model of the Earth that showed global wind patterns, convection cells, doldrums, jet streams, and latitudes. Students also had to attach an “in-their-own-words” definition to each term they identified on their diagram. Students were given two days of in-class time for the project to be introduced and completed and about half of students finished in-class while the other half took more time to complete the project up until the due date, the end of the week in which it was assigned. During this instructional period, students also completed two webquests. The first webquest was designed to help students recognize surface currents on a map with their main task being to track which currents were notably “warm” and which were “cool” and determine the deciding factor of their respective temperatures: their origin (Equator or Poles). After this webquest, students had a half-day of direct instruction via guided notes on the three major types of ocean currents.

Students closed this day with another webquest, created by NOAA and modified by myself, related to the El Nino Southern Oscillation. Students in this webquest used real satellite data of sea surface temperature, using both graphs and maps to interpret the data. Their closing task was to use data they sourced from the NOAA database to determine if an El Nino event occurred in the summers of 2015-2016. These activities were meant to shape student understanding about the content, and give them multiple opportunities to engage with new content beyond their daily bellringers and previous completion of guided notes following the associated textbook chapter.

To evaluate the effectiveness of the pre-test and daily formative assessment model, the students were given a modified post-test that was reduced to seven multiple-choice questions most related to the recent content students had learned. This post-test was administered in two parts, the first part was a diagram that students had to complete, and the second part was seven selected multiple-choice questions from the pre-test that students already took. When students took the pre-test, they were made aware that some of the same questions would be used on their post-test, so they were not allowed to keep any paper copies of the pre-test. The second part of the post-test was submitted into a Google Form, similar to the pre-test, that was recorded on a Google Sheets document and graded using Flubaroo. This post-test was used as a summative assessment for students to demonstrate what knowledge they retained from the lessons that reflected their learning objectives for the unit. Students received a formal grade for their post-test performance that combined their scores on Part One and Part Two of the post-test. To allow students time to reflect on their performance and make corrections, the test was passed back to students and the answers were reviewed with all class periods. Students were asked to record the correct answers to questions on their test documents and reflect on their studying habits on a separate paper where they graph their assessment scores and write about how they studied for

each assessment. This graph paper is located in a folder labeled with the students' names, where all their summative assessments for the semester are passed back and located. Students are free to access these folders at any point to review previous information covered, and are encouraged to use them to prepare for any comprehensive assessments given, such as their semester exam. For students to reflect on their learning, each time a summative assessment is passed back, students graph their scores on a provided bar graph titled "Science Student Performance", where students record the title of the assessment on the x-axis, and their percentage score on the y-axis. This allows students to track their own performance throughout the semester, and allows them to pinpoint which content they may have most struggled with. To encourage further self-reflection, each time students record an assessment score, they write on the back of this graph the date and title of the assessment and state how they studied, and how they plan to study in the future.

Data and Analysis

The data showed a marked improvement in student test scores between the pre-test and post-test given as seen with Figures 4 and 5. Each question on the pre-test that was repeated on the post-test showed an improvement in the overall percentage of students that answered the question correctly. The overall average score on the pre-test was 5 points out of 14 available points, or a percentage score of 35.7, as seen in Figure 1. If students were purely guessing on the pre-test's 14 questions, based on the options for the matching, the number of four-choice multiple-choice questions and the number of three-choice multiple choice questions, the expected score would be a 35.7 percent which is what was seen in the results. The overall average score on the post-test questions was a 6.61 out of 7 available points, for an average of 94.4 percent correct. When using these values, the student scores improved by 58.7 percent. When accounting for the percentage of points earned when the questions unique to the pre-test

are excluded, the average score was a 41 percent. Students improved from a 41 percent to a 94.4 percent for the seven questions on the post-test taken directly from the pre-test.

To further understand the results on the pre-test and the post-test, the range of scores should be compared, along with the lowest and highest scores earned on both assessments. The lowest score earned on the pre-assessment was a 1 out of 14 points, or a 7.1 percent. The lowest scoring question on the pre-test had 16.4 percent correct answers. The highest score earned on the pre-test was a 9 out of 14, or a 64.3 percent. The highest scoring question on the pre-test had 71.2 percent correct answers. On the post-test, the lowest score earned was a 4 out of 7, or a 57.1 percent. The highest score earned on the post-test was a 7 out of 7, or a 100 percent. The 100 percent was also the mode on the post-test. The lowest scoring question on the post-test showed an 89.3 percent correct answers, while the highest scoring question on the post-test had 100 percent correct answers.

As another method to show growth on an individual student basis, the pre-test scores and post-test scores of one period were plotted in a scatter plot (Figure 3). This class period was chosen because it is representative of the greater seventh grade population, with a range of students including those who have been identified as “gifted” in science, and a few students on Individualized Education Plans (IEPs). This class period shows a range of student achievement outside of this particular pre-test and post-test cycle. Each point on Figure 3 represents an individual student’s performance on the pre-test and post-test. Notable from this figure is the range of scores on the post-test that came from students that achieved the same score on the pre-test (a 28.6 percent). These five students performed from the low of a 58.8 percent to the high of an 88.2 percent on the post-test. For these two students, a normalized gain value can be calculated as 0.42 for the student that earned a 58.8 percent on the post-test to a 0.83 for the

student that earned an 88.2 percent on the post-test. The normalized gain is described by Hake (1998) as a calculation that is found by taking “the ratio of the actual average gain (%post-%pre) to the maximum possible average gain (100-%pre)”. This calculation can be used to determine the effectiveness of a course (or unit), with values between 0.3 and 0.6 meant to be an intermediate gain, and levels above 0.7 taken to mean a large gain (Hake 1998). In the case of these two individual students who both received the same score on the pre-test, one student showed intermediate gains and one student showed large gains.

Total Average	
Points	5
Percentage	35.7

Total Average	
Points	6.61
Percentage	94.4

Figure 1. Total Average on Pre-Test

Figure 2. Total Average on Post-Test

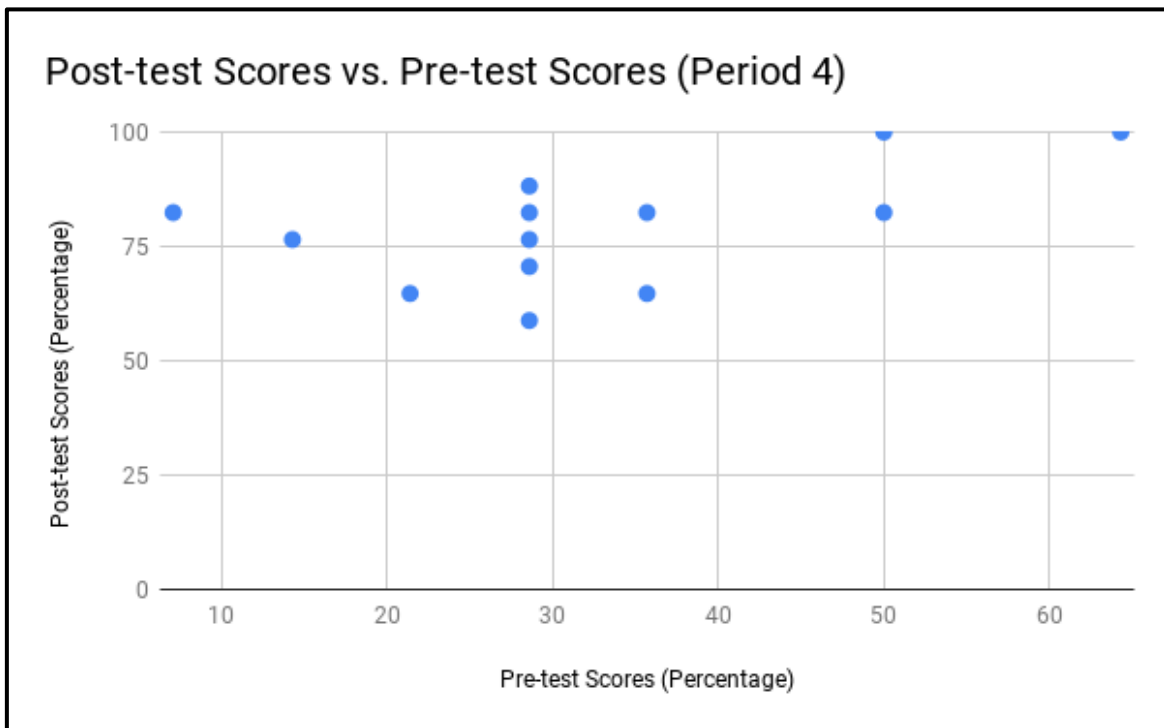


Figure 3. Student Scores for Period 4 Plotted Post-Test versus Pre-Test

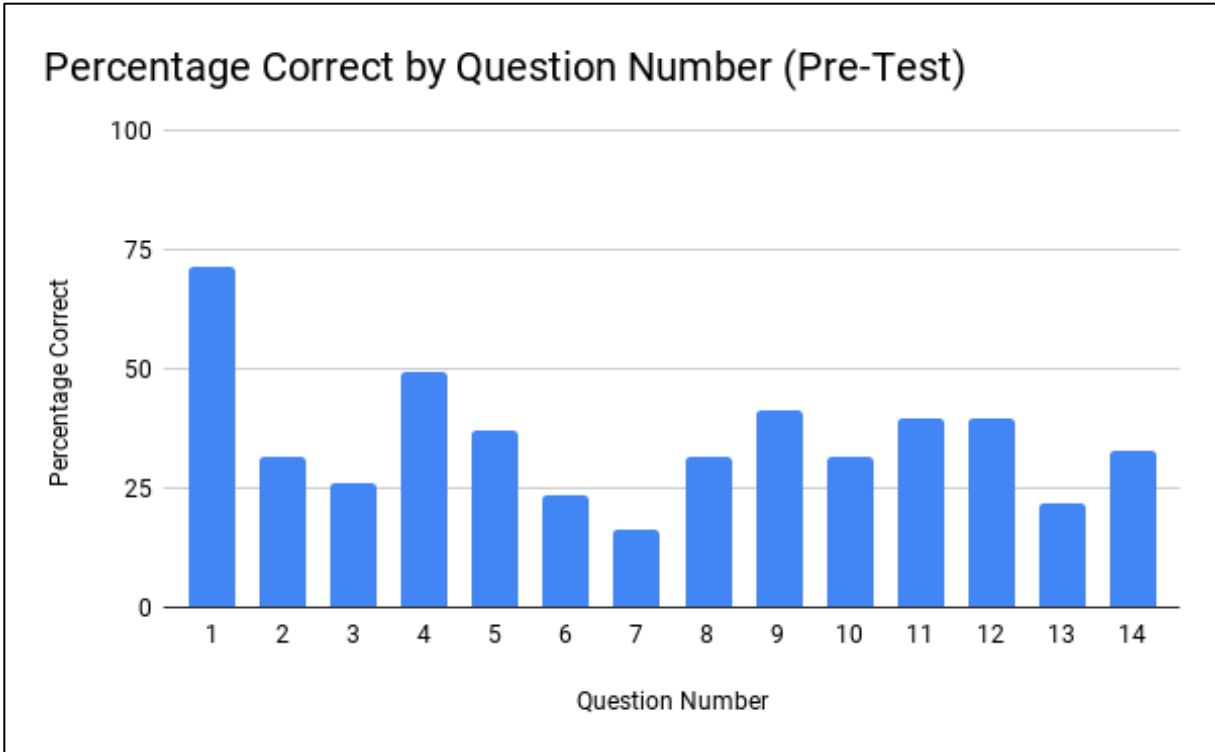


Figure 4. Percentage of Students Answering Correctly by Question Number on Pre-Test

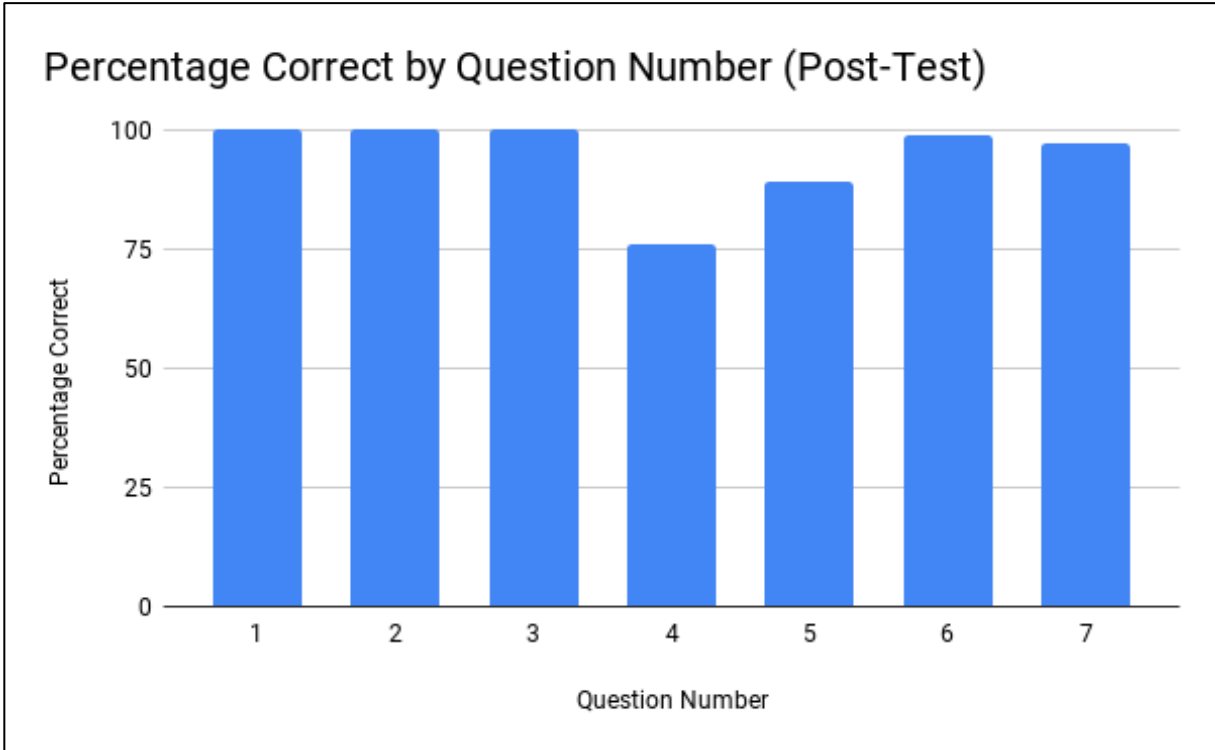


Figure 5. Percentage of Students Answering Correctly by Question Number on Post-Test

Conclusions/Implications/Limitations

Based on the data collected, the method of using a pre-test to expose students to the material they will be covering before the lessons begin was part of an effective teaching strategy in all four of the seventh-grade science classes covered by this study. For these specific students, the pre-test and post-test model showed an average improvement of 58.7 percent, with student scores improving, on average, from a 35.7 percent on the pre-test to a 94.4 percent on the post-test. In this classroom, student summative assessment scores (post-test scores) improved after they had completed a brief formative assessment in class (the pre-test) followed by direct instruction and creating a project to cover the content. These results are consistent with other research done in the field, showing that formative assessment practices, including pre-tests, can improve learning outcomes in students. For this classroom in the future, it might be beneficial to continue the practice of designing pre-tests as a form of formative assessment before instruction on a new unit begins.

However, it is difficult to conclude that the pre-test alone is responsible for the increase in student performance on the summative post-test. Students also engage in formative assessment on a daily basis in the classroom through the answering of “bellringer” questions meant to activate background knowledge or provide clues about the day’s content. Students have access to their learning objectives for each lesson, each day. Students also had direct instruction from a teacher and completed a project that covered the content presented on the pre-test and post-test. Students in the district where these assessments were administered are high-achieving and have consistent parental support. In all four class periods studied, students were curious about their performance on the pre-test and some even asked to keep the pre-test document to reference throughout the unit. Students in the district studied also have access to technology in a one-to-

one setting that allows them to complete assignments, projects, and assessments online. This technology usage is a factor that should be considered when evaluating the true “cause” of the improvement on the post-test, as resources should not be ignored completely, nor should the possibility of academic dishonesty as students were not blocked from accessing information online as they were taking the post-test, beyond the teacher circling to observe and answer questions.

To improve this study if I were to repeat it in the future, I would do a more traditional pre-test and post-test model where questions and order of questions were kept the same. For this experiment, some learning objectives meant to be assessed by the original pre-test were not assessed on the post-test from time restraints due to state testing requirements. If I were to repeat this study, I would also add an interest survey for students to determine where their base of knowledge was even before a pre-test. Additionally, I would survey students following the post-test to ask them if they recognized any of the questions from the pre-test and if they felt taking the pre-test helped prepare them for the upcoming unit. This would help better link pre-test perceptions with performance on the post-test and expand the study to include some qualitative measures along with the quantitative assessment scores. Student scores could also be evaluated using the normalized gain approach introduced by Hake (1998) and survey questions could help draw conclusions about the potential differences in impact of formative assessment, test preparation strategies, and preferred classroom activities for students that show intermediate gains versus students that show large gains. Because the pre-test and post-tests were brief, it allowed them to be taken without using an entire class period, and students were aware the pre-test was not taken for a grade, which may have reduced any test anxiety. On the same note, however, students being aware the pre-test was not taken for credit may have finished it without

truly attempting their best effort or fully reading through all questions and answer choices. This potential for lack of effort on the pre-test may have kept pre-test scores artificially low and resulted in a greater improvement on post-test performance. Though post-test scores improved across all four class periods of seventh-grade science, there were limitations to the study and multiple variables that could have impacted post-test performance other than the pre-test students took. I would use this system in the future, because it helped me as the teacher make sure that I covered content that I was going to assess on the post-test, and allowed me to tweak lessons to better communicate learning objectives and content with students.

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Name: _____

Period: _____

Pre-Test Global Weather Patterns Test

1-3. What are the names of the three major convection cells that circulate and move air in the Earth's atmosphere?

1. _____, 2. _____, 3. _____

Word Bank for Questions 1-3:

A. Polar B. Ferrel C. Convective D. Rex E. Hadley F. Longitudinal

4. _____ How does air move based on air pressure?

- a. From areas of high pressure to areas of low pressure
- b. From areas of low pressure to areas of high pressure
- c. From areas in the north to areas in the south
- d. From the Atlantic Ocean to the Pacific Ocean

5. _____ Why does ocean water circulate?

- a. Changes in amount of nutrients available
- b. The Earth's daily rotation
- c. The tilt of the Earth on its axis
- d. Differences in temperature and salinity

6. _____ Which pressure system can cause large amounts of precipitation and carries the possibility of thunderstorms?

- a. High Pressure Systems
- b. Low Pressure Systems
- c. Both Pressure Systems

7. _____ Which pressure system is associated with clear skies and mild weather?

- a. High Pressure Systems
- b. Low Pressure Systems
- c. Both Pressure Systems
- d. Neither Pressure System

8. _____ What are ocean areas called where there is little wind movement?

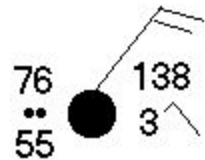
- a. Shipwreck Latitudes
- b. Doldrums
- c. Reverse Circulation Points

9. _____ What is the phenomenon of wind deflection caused by Earth's rotation?
- Coriolis Effect
 - Strong's Effect
 - Rotation Effect

10. _____ In a high pressure area, winds rotate:
- Clockwise
 - 60 degrees
 - Towards the Equator
 - Counterclockwise

11. _____ In a low pressure area, winds rotate:
- Clockwise
 - 60 degrees
 - Towards the Equator
 - Counterclockwise

For questions 12 and 13, reference the following station model:



12. _____ Based on this model, what is the air temperature?
- 76°F
 - 55°F
 - 138 K
13. _____ Based on this model, what is the cloud cover?
- Clear skies (0- 10% obstructed)
 - Overcast skies (20-80% obstructed)
 - Completely cloudy skies (100% obstructed)
14. _____ An air mass that formed over the center of Canada would be called...
- Continental Polar
 - Continental Tropical
 - Maritime Polar
 - Maritime Tropical

Post-Test Global Weather Patterns Part II

1-3. What are the names of the three major convection cells that circulate and move air in the Earth's atmosphere?

1. _____, 2. _____, 3. _____

Word Bank for Questions 1-3:

A. Polar B. Ferrel C. Convective D. Rex E. Hadley F. Longitudinal

4. _____ How does air move based on air pressure?

- a. From areas of high pressure to areas of low pressure
- b. From areas of low pressure to areas of high pressure
- c. From areas in the north to areas in the south
- d. From the Atlantic Ocean to the Pacific Ocean

5. _____ Why does ocean water circulate?

- a. Changes in amount of nutrients available
- b. The Earth's annual revolution
- c. The tilt of the Earth on its axis
- d. Differences in temperature, salinity, and wind

6. _____ What are ocean areas called where there is little wind movement?

- a. Shipwreck Latitudes
- b. Doldrums
- c. Reverse Circulation Points

7. _____ What is the phenomenon of wind deflection caused by Earth's rotation?

- a. Coriolis Effect
- b. Strong's Effect
- c. Rotation Effect