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Developing authentic summative assessments that correlate to the Next Generation Science Standards for a middle school science classroom

Nick Bushkofsky
University of Northern Iowa

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Abstract

A major shift in science education has occurred in the state of Iowa and it involves the adoption of performance expectations from the Next Generation Science Standards (NGSS) standards. The new curriculum demanded by NGSS will instigate a learning shift for science teachers in Iowa. They must re-format lessons and assessments to encompass their target NGSS standards. This creative component has analyzed six targeted NGSS performance standards and has developed high quality summative authentic assessments correlated to the targeted NGSS standards.

Developing Authentic Summative Assessments that Correlate to the Next Generation Science

Standards for a Middle School Science Classroom

Nick Bushkofsky

University of Northern Iowa

This creative component was completed in partial fulfillment for a
Master of Arts in Science Education.

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Abstract

A major shift in science education has occurred in the state of Iowa and it involves the adoption of performance expectations from the Next Generation Science Standards (NGSS) standards. The new curriculum demanded by NGSS will instigate a learning shift for science teachers in Iowa. They must re-format lessons and assessments to encompass their target NGSS standards. This creative component has analyzed six targeted NGSS performance standards and has developed high quality summative authentic assessments correlated to the targeted NGSS standards.

Developing Authentic Summative Assessments that Correlate to the Next Generation
Science Standards for a Middle School Science Classroom

Chapter 1: Introduction

Assessment is a critical component of every classroom. An effectively written assessment informs the teacher and the student what the student knows and is able to do in terms of knowledge and skill. As I currently reflect on my classroom and teaching practices, I want to improve the way I assess students at the end of instruction. A professional goal of mine is to incorporate more summative assessments that are relevant for my students' lives. Currently, many of my summative assessments contain tasks that are more low level and require only a basic understanding of the targeted concepts. The tests focus on recall of information in multiple choice, short answer, and matching style questions. An issue with this is that the ultimate end to my unit is a standardized test. This only shows students that learning is simply memorizing and studying (Wiggins, 1990). As the science standards in Iowa are changing and the needs of my students have changed, I am compelled to develop authentic assessments that will align with the Next Generation Science Standards (NGSS) and will be applicable for my students' future.

In October of 2014 an Iowa Science Review Team was created as a result of Governor Branstad's Executive Order 83. The review team was composed of nineteen Iowans and consisted of early childhood through higher education educators, and employees of agricultural, medical, aerospace engineering, and youth outreach programs. The purpose of this team was to review Iowa's science standards and also the science standards from other states, analyzing feedback from the public, and issuing a recommendation to the Iowa Department of Education director for an adoption of new standards. This included determining whether the state of Iowa would adopt all or part of the NGSS standards. The 2015 Iowa Science Standards Review Team

has met and has made recommendations on which NGSS standards the Iowa Core will adopt.

The Science Standards Review Team made the following recommendation in the Science Standards Review Team Report:

“We recommend the Next Generation Science Standards performance expectations be adopted as Iowa’s science standards, grade specific for grades K-8 and grade span for grades 9-12, acknowledging the importance of integrating the disciplinary core ideas, cross-cutting concepts, and science and engineering practices in achieving these standards.” (“Science Standards Review Team Report 2015”, pg. 5)

The team also noted that the standards provided a focus on college and career readiness, preparation of scientifically literate citizens, and other skills important to the field of science and to the integration of multiple disciplines and skills.

Since the Science Review Team made their recommendation to the Iowa Board of Education, the board adopted the performance expectations of the Next Generation Science Standards with some modifications. A state board member was quoted saying that the standards will help students gain the “real-world knowledge and skills” that they need to be successful in college and as employees (“State Board of Education adopts new science standards,” 2015). The NGSS standards are also written as performance expectations, which will be difficult for teachers to understand and ultimately write assessments for (“NSTA Position Statement”, 2013; Workosky & Willard, 2015).

The new framework for science education requires teachers to use a variety of assessment tools that contain complex tasks (Pellegrino, Wilson, Koenig, & Beatty, 2014). This creates a challenge for science teachers because these assessments are much different from the traditional

assessments being used. Even though the framework for science and the NGSS are requiring the shift in assessments, these assessments are not yet created and will need to be created by teachers. The assessments are going to be difficult to create, at first, because they are different from standardized tests. This creative component allows me to research and develop effective ways for creating the complex, authentic based assessments. By creating authentic assessments that correlate to the NGSS my students will be appropriately challenged and these assessments will provide the guides to help science teachers in my district, and in the state, create their own NGSS assessments.

While the NGSS highlight the importance of authentic assessments, there is not agreement on what constitutes a high quality authentic assessment. Many researchers have worked to clarify the definition of an authentic assessment. A high quality authentic assessment should incorporate knowledge, skills, tools, and resources students will use in their future careers and as members of society (Gulikers, Bastiaens, & Kirschner 2004; Palm, 2008; Frey, Schmitt, & Allen, 2012; Frey & Schmitt, 2007). Researchers have also described what the characteristics are for a high quality authentic assessment and some of the misconceptions regarding the features of an authentic assessment that will be addressed in detail in chapter two (Cronin, 1993; Frey, Schmitt, Allen, 2012; Gulikers, Bastiaens, & Kirschner, 2004; Moon, Brighton, Callahan, & Robinson, 2005).

The purpose of this creative component is to develop authentic summative assessments that correlate to the current curriculum being taught in an eighth grade science classroom along with NGSS standards and practices. As I develop the assessments, I will learn how to best create a high quality authentic assessment that is correlated to the NGSS standards. I will be able to share my new learning with the science education staff within my district.

Chapter 2: Literature Review

Definition & Characteristics of Authentic Assessments

In order to correctly develop authentic tasks, it is necessary to understand what “authentic assessment” means. There have been a number of researchers who have reviewed the literature to determine a consistent definition for authentic assessment. Palm (2008) reviewed a number of literature sources in order to determine a more concrete definition for performance based assessments and authentic assessments. In order to do this, the researcher analyzed the meanings found among multiple sources by searching for the words “performance assessment”, “authentic assessment”, “authenticity,” and “authentic” from the ERIC and MATHDI databases. Palm found authentic assessments are related to the student’s life beyond school, curriculum and classroom practice. Also, authentic assessments should allow students the power to construct knowledge and use appropriate tools and skills he or she would use beyond school in society.

Frey and Schmitt (2007) analyzed many journal articles, position papers, thought pieces, and textbooks that included definitions of commonly used assessment terms. Their focus was on the terms “performance assessment”, “authentic assessment”, and “formative assessment”. Through their research, the researchers found an authentic assessment is only authentic if “the conditions match real-world contexts” (pg. 416). The researchers also noted a performance assessment is not necessarily an authentic assessment because a student may be asked to complete some type of performance but the performance may not be set in a real-world context.

Moon, Brighton, Callahan, and Robinson (2005) explained students should create their own knowledge and authentic assessments allow students to do this. The researchers also described many characteristics of an authentic assessment. They said an authentic assessment should: focus on essential concepts, lead to other problems, be easily done within a school and

classroom, produce a high quality product, promote the development of the student, have specific criteria that is explained ahead of time, have more than one answer or product, and have a scoring guide focused on the task. The researchers also stressed that there must be clear communication between the student and the teacher so the student is aware of what is expected of him or herself.

Gulikers, Bastiaens, and Kirschner (2004) defined authentic assessment as the following: “assessment requiring students to use the same competencies, or combinations of knowledge, skills, and attitudes, they need to apply in the criterion situation in professional life.” The researchers also identified five dimensions for an authentic assessment: 1) Task: the task should relate to a possible part of the students’ professional practice later in life. 2) Physical Context: the assessment should reflect knowledge, skills, and attitudes that would be used in the professional life. 3) Social Context: The task should incorporate social conversations if it would necessarily do so in the students’ professional life. 4) Assessment Result or Form: The assessment should be a product that the students create and involves multiple tasks. 5) Criteria and Standards: There should be set, valued criteria that relate to the content and the standards must be appropriate for the grade level. The researchers completed a study involving participants of students and teachers from a nursing college. They used an electronic group support system as their research tool that facilitated decision-making. The researchers provided the participants four case descriptions of assessments varied in their amount of authenticity based on the five dimensions of their model for authentic assessment. They determined participants found the task itself to be the most important overall and the social context dimension to be the least important to the authentic assessment.

Frey, Schmitt, & Allen (2012) reviewed 109 scholarly publications by 100 different primary authors to determine characteristics of authentic assessments and to attempt to define authentic assessment. The researchers established the following broad categories to describe an authentic assessment:

- Context
 - Realistic activity or context
 - Performance-based task
 - Cognitively complex task
- Role of the student
 - Defense of the answer or product is required
 - The assessment is formative
 - Students collaborate with each other or the teacher
- Scoring
 - Criteria are known or are developed by the student
 - Multiple indicators or portfolios are used for scoring
 - Performance expectation is mastery

The researchers concluded the crucial elements for an authentic assessment involve the student. The student should find the assessment cognitively complex and have intrinsic interest for the assessment. Also, the student should develop or evaluate their own personal skills and abilities that have value beyond the actual assessment.

In “A Framework for K-12 Science Education” (2015), the National Research Council describes many science assessments to still be in a “pencil-paper” and “multiple-choice” format. Even though the Framework does not directly address the main components of using authentic

summative assessments, it does address the limitation of the traditional pencil-paper multiple choice testing formats. As this type of format can effectively assess some skills and recall of information, multiple-choice tests do not adequately assess student understanding. These types of assessments also do not measure students' ability and understanding of the processes of science such as creating scientific explanations and designing and running a scientific investigation. The NRC closes this section of their recommendation by calling for a more "inclusive, focused, and authentic science education experience for all students (pg. 265)." This not only has implications for instruction but also for assessment. If students are going to be exposed to more authentic learning opportunities, then the assessments they are given must also be authentic.

Next Generation Science Standards

The Next Generation Science Standards were created to be "rich in content" and provide students with an "internationally-benchmarked science education" ("Next Generation Science Standards, n.d.) The standards were first released to the nation on April 9, 2013. The NGSS standards were developed through a collaborative, state-led process and are based upon the Framework for K-12 Science Education which was developed by the National Research Council (NRC). The NGSS standards are written as performance-based expectations. This means, the standards describe what students should be able to know and do at the end of instruction ("NSTA Position Statement", 2013). The expectations are not meant to be used as curriculum nor tell teachers what to do during instruction. Teachers will need to make personal decisions about what needs to be taught so students are able to do and know what the performance assessment describes at the end of instruction (Workosky & Willard, 2015).

There are three dimensions outlined in the NGSS that are provided by the NRC (“Three dimensions”, n.d.). The first dimension is the practices of science and engineering or practices that scientists would be involved in on a regular basis. The practices specifically relate to scientific inquiry but also the engineering design process that is incorporated in many of the NGSS standards.

The second dimension relates to the cross-cutting concepts. These concepts help include all or multiple domains of science (i.e. earth, physical, and life science) for one specific concept. Appendix G published by the NGSS in 2013 describes the crosscutting concepts as a way to link specific science content and other disciplines. This dimension also incorporates multiple disciplines of science into one so students have a better, overall understanding of the content they are studying. A few examples of the cross-cutting concepts are: patterns, cause and effect, energy and matter, and structure and function.

The third and final dimension is called “Disciplinary Core Ideas”. These core ideas are the broad standards that incorporate all disciplines of science and are considered to be the most important aspects of science. These are the closest component of the NGSS to the previous set of national science standards and focus on the specific concepts within the area of life, physical and earth and space science.

The appendix F of the Science and Engineering Practices for the NGSS describes how students will best be assessed in the field of science. “In the future, science assessments will not assess students’ understanding of core ideas separately from their abilities to use the practices of science and engineering. They will be assessed together, measuring not only what students know in terms of content knowledge; but also, how well the student can use their understanding to investigate the natural world through the practices of science inquiry, or how well they can solve

meaningful problems through the practices of engineering design” (pg. 1). Authentic assessments will provide the teacher with the ability to assess content knowledge through the students’ proficiency with the science and engineering practices. The eight science practices are also referenced in appendix F of the Science and Engineering Practices. The practices are correlated directly to the 2012 NRC Framework. The eight science and engineering practices are as follows:

- Asking questions (for science) and defining problems (for engineering): Students at all grade levels should be able to ask questions about readings, investigations, observations, etc. The questions and problems should lead the student to other practices.
- Developing and using models: The NGSS defines models as “diagrams, physical replicas, mathematical representations, analogies, and computer simulations.” Students should be able to create, modify, and analyze models based upon evidence of the real world.
- Planning and carrying out investigations: Students should be able to design a controlled investigation that will provide the student with evidence to support their conclusions. If students are designing investigations for an engineering problem, they should compare, create, and analyze solutions that would best solve the problem.
- Analyzing and interpreting data: Students should be able to analyze data as evidence that supports their conclusions to a question or engineering problem. In order to do this, students should be able to use an array of tools for analyzing their data.

- Using mathematics and computational thinking: Mathematics is a vital tool that students need to understand science. Students are expected to be able to use mathematical relationships to represent physical variables and make predications based upon quantitative relationships. This practice also involves using computer software to collect, measure, record, and process data.
- Constructing explanations (for science) and designing solutions (for engineering): Students are expected to be able to construct their own explanations from a science investigation and design solutions to an engineering problem.
- Engaging in argument from evidence: Students engage in arguments in order to understand the culture of the science community and how to apply science and engineering to benefit society. The arguments allow students to listen, compare, and evaluate peers' ideas. Students' arguments are expected to be based on evidence and reasoning.
- Obtaining, evaluating, and communicating information: The goal of this practice is to make students a “critical consumer of information about science and engineering.” Meaning, students must be able to read, interpret, and communicate scientific information effectively based upon the scenario. This also includes analyzing information for flaws as well as identifying sources of error within an investigation.

The editors Pelligrino, Wilson, Koenig, and Beatty (2014) of the book from the Committee on Developing Assessments of Science Proficiency have discussed how the new NGSS standards and framework will require different assessments. The new standards force educators to rethink the way assessments can be used within the classroom. Standardized tests

do monitor student learning, however they do not force students to demonstrate deep understanding of the new knowledge they have constructed nor do they require students to demonstrate ability to use the science and engineering practices. The new framework requires new assessments with a “range of tools designed to meet a variety of needs for information...” (pg. 16) The NGSS standards will also require teachers to develop assessments that meet the diverse needs of students and that contain “complex tasks” (pg. 16).

Stacey Goldstein is a director for the School of the Future in New York City. She specifically describes science authentic assessments as something that would have the students participating in activities similar to the ones engaged in by a scientist (“School of the Future”, 2011). These activities would involve the science and engineering practices outlined by the NGSS as they are the process of science.

Bloom’s Taxonomy

The authentic summative assessments created for the NGSS curriculum should require multiple levels of higher order thinking, one of the important characteristics of high quality authentic assessments. Bloom’s Taxonomy outlines the different levels of thinking. Jessica Shabatura (2013) describes the different classification of Bloom’s taxonomy:

1. Remembering: Retrieving, recognizing, and recalling information (student actions: list, recite, outline, define, name, match, quote, recall, label, recognize).
2. Understanding: Constructing meaning of information (student actions: describe, explain, paraphrase, restate, summarize, interpret, discuss).
3. Applying: Applying facts, rules, and/or concepts to new ideas (student actions: calculate, predict, apply, solve, illustrate, use, demonstrate, determine, model, perform, present).

4. Analyzing: Breaking-down the information into different parts to determine relationships (student actions: classify, break down, categorize, analyze, diagram, illustrate, criticize, simplify, associate).
5. Evaluating: Judging the value of information or ideas (student actions: choose, support, relate, determine, defend, judge, grade, compare, contrast, argue, justify, support, convince, select, evaluate).
6. Creating: Combining information to make something new (student actions: design, formulate, build, invent, create, compose, generate, derive, modify, develop).

These six levels of thinking should guide the creation of the authentic assessments. By incorporating multiple levels and making sure that higher levels of thinking like Evaluating and/or the Creating are part of the assessment, the assessment will better meet the characteristics of high quality authentic assessments.

Chapter 3: Project

As summarized in Chapter 2, a high quality authentic assessment will have multiple components of the following characteristics. The first set of characteristics is based upon what the student is doing or demonstrating in order to successfully complete the assessment:

- The student creates/applies their own learning.
- The student uses tools, skills, knowledge needed beyond school.
- The student produces a high quality product that has more than one possible answer.
- The student must defend their answer(s).
- The students collaborate with each other or the teacher.
- The student can demonstrate knowledge or skills through more than one way.

The next set of characteristics is related to the actual task of the assessment:

- The task relates to the field of science and/or engineering.
- The task is directly correlated to the targeted NGSS performance standard.
- The task incorporates multiple Science and Engineering Practices as outlined by the NGSS standards
- The task incorporates multiple levels of Bloom's Taxonomy and includes Creating and/or Evaluating

The above list of authentic assessment characteristics has been transformed into a checklist to be used as an informal indicator of the degree to which each of the assessments developed for this project exemplifies a high quality experience. At the end of each summative assessment is a completed checklist which serves as an indicator of authenticity of the assessment.

Each of the authentic assessments created as part of this project will contain student pages along with teacher pages. The student pages will contain directions, questions, and, where

applicable, information on how they will be scored for the assessment. The teacher pages will contain directions for administering the assessment, materials needed, target NGSS standard(s), and the rubrics to grade the assessment. A sample template for each assessment is shown in

Figure 1.

Figure 1:

NGSS Assessment Teacher Page Template

Assessment Name

Next Generation Science Standards Performance Expectation(s):

Assessment Overview:

Materials Needed:

Directions for administering the assessment:

Scoring:

Student Pages (Actual Assessment):

Along with the information for the teacher pages, there is a brief description of a possible unit outline presented before each assessment. The unit outline precedes the summative assessment so the reader understands the general concepts that need to be taught in order for the summative assessment to be given. After each brief synopsis of the unit is the key vocabulary students must know in order to successfully complete the summative assessment.

Assessments

Assessment #1: Earth and Human Activity

Possible Unit Outline: There are two main components students must understand in order to complete this assessment. The first part is understanding science knowledge specific to the content of water quality. Students may complete activities that help them measure water quality. For example, students could determine and practice chemical assessments and biological assessments that can be used to measure the quality of water. Students also need to be aware of the activities and uses that happen within their watershed. The second component of the water quality unit is related to engineering. Even though students should have a basis of scientific practices, the engineering practices are a little different. Students will need to demonstrate understanding of the engineering design process.

Key Unit Vocabulary: water quality, pollution, watershed, criteria, constraints, solution, engineering design process, and model.

NGSS Assessment Teacher Pages Earth and Human Activity – Water Quality – Assessment

Next Generation Science Standards Performance Expectation(s):

MS-ESS3-3: Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

Assessment Overview:

This assessment involves an engineering design problem in which students must understand the problem and determine a human activity that would cause the problem. Then students describe criteria and constraints for the problem, design a solution, and evaluate their solution based upon the criteria. This assessment is written for a unit that would be based on water quality and how human choice and actions can negatively influence the water quality. The problems generated could be changed to fit a different unit that was based upon human impact on the environment.

Materials Needed:

- Student assessment pages
- Water Quality tests (ex: biological assessment, chemical assessments, physical assessments, habitat assessments)
- Possible materials for their model

Directions for Administering the Assessment:

On the first day, hand out the student pages and read through the problem plus each step with the students. Allow students to brainstorm possible solutions this day and then submit a short plan or proposal. This will allow you to determine which students may need more assistance or re-direction to adequately complete the assessment. The assessment should take approximately four, 45-minute class periods to successfully complete.

Scoring:

Component	Outstanding	Building	Sketchy
Human Activity	Correctly identifies and explains a human activity/choice that could cause the pollution.	Correctly identifies a human activity that could cause the pollution.	Human activity is not related to the extreme pollution problem.
Criteria & Constraints	Correctly includes all major criteria and constraints. Criteria and constraints demonstrate knowledge of the engineering design process.	Missing minimal (1-2) major criteria and/or constraints. Student still demonstrates knowledge of the engineering process.	Does not demonstrate knowledge of the engineering process as many criteria (3+) or constraints are missing OR are incorrect.
Solution & Monitoring Plan	The solution is sufficiently described without major questions. The solution would fix or help the pollution problem. The solution is supported with a monitoring program that includes multiple (5+) assessments for the river.	The solution is described but the reader is left with some questions. OR The monitoring program is missing major assessments of the river.	The solution is quite vague OR the monitoring program is missing.
Model	The model (picture, diagram, flow-chart, or	The model needs more detail to be an accurate	The model is not related to the solution and/or is

	a mini replica) is an accurate and clear representation of the solution.	and clear representation of the solution.	not a clear representation of the process.
Evaluation	The student adequately and accurately reflects upon each of their criteria and determines the overall effectiveness of their solution.	The student adequately and accurately reflects upon each of their criteria. Is missing an overall effectiveness of their solution.	The student's reflection is limited, as it does not mention each one of their criteria.

Student Pages (Actual Assessment):

Earth and Human Activity – Water Quality – Assessment

Problem: The local river in your farming community (population of about 6,500 people) is slowly becoming more polluted. There is more soil build-up around the edges of the river and an increase in algae growth. Also, the biological assessment shows a decrease in low pollution macroinvertebrates and an increase in high pollution macroinvertebrates. All chemical assessments are not in their typical levels. Many members of the community are extremely disappointed, as they cannot use their river for recreational purposes.

Step 1: Based on the problem, identify a human activity that could be the cause for the decrease in water quality. Be sure to describe the human activity and explain why this activity is occurring. Online research and materials from our unit may be used in answering the questions.

Human Activity:

Source of Information: _____

Step 2: Identify the criteria and constraints for the problem. Hints: Be as specific as possible. Also, you do not have to consider a budget as part of your constraints.

Criteria:

Constraints:

Step 3: Design a solution AND develop a monitoring plan (use at least 5 or more water quality assessments) that would fall within your constraints but meet your criteria to solve, fix, or help the water quality problem. Your solution needs to include a one-paragraph explanation and a model (picture, diagram, flow-chart, or a mini replica) to describe your solution. Please attach or build your model (whichever is more appropriate for your proposed solution.)

Authentic Assessment Checklist: Earth and Human Activity - Water Quality

- The student creates/applies their own learning.
- The student uses tools, skills, knowledge needed beyond school.
- The student produces a high quality product that has more than one possible answer.
- The student must defend their answer(s).
- The students collaborate with each other or the teacher.
- The student can demonstrate knowledge or skills through more than one way.
- The task relates to the field of science and/or engineering.
- The task is directly correlated to the targeted NGSS performance standard.
- The task incorporates multiple Science and Engineering Practices as outlined by the NGSS standards
- Asking Questions/Defining Problems
 - Developing & Using Models
 - Planning & Carrying Out Investigations
 - Analyzing & Interpreting Data
 - Using Math/Computational Thinking
 - Constructing Explanations

Engaging in Argument from Evidence

Obtain, Evaluating, & Communicating Information

The task incorporates multiple levels of Bloom's Taxonomy and includes Creating .
and/or Evaluating

Remembering

Understanding

Applying

Analyzing

Evaluating

Creating

Assessment #2: Kinetic Energy

Possible Unit Outline: This unit will include activities and research that has students learning about the vocabulary terms kinetic and potential energy. Students could research how kinetic and potential energy is applied to roller coasters at an amusement park. From here, students should create investigations and carryout these investigations to see how speed and mass are related to kinetic energy. The unit can even get as specific as trying to determine the correlation between mass and kinetic energy. There should also be direct instruction and practice on how to appropriately make graphs and analyze data from graphs. This can be incorporated when students are analyzing data from their speed, mass, and kinetic energy investigations.

Key Unit Vocabulary: kinetic energy, potential energy, speed, mass, linear, nonlinear, and slope.

NGSS Assessment Teacher Pages

Kinetic Energy Assessment

Next Generation Science Standards Performance Expectation(s):

MS-PS3-1: Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object.

Assessment Overview:

This assessment is intended to be used after students have done investigations in which they discovered the relationships between kinetic energy and mass and kinetic energy and speed. The assessment will test student understanding of those specific concepts and also the student's ability to analyze data.

Materials Needed:

Student Pages of Kinetic Energy Assessment

Directions for Administering the Assessment:

Hand-out assessment to each student. Some students may want a calculator for certain problems.

Scoring:

The scoring for this assessment is attached after the student pages. Suggested point values and answers are given.

Student Pages (Actual Assessment):

Graph paper used from:

<http://www.teachingideas.co.uk/graphs/graph-templates>

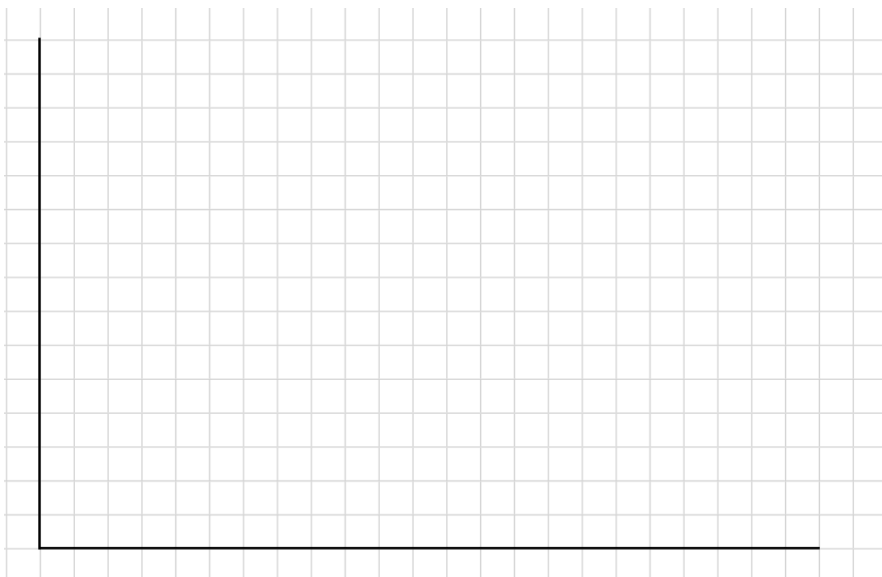
Kinetic Energy Assessment

1. John is curious about how kinetic energy relates to both speed and mass. Read each scenario below about how John learns the relationships between kinetic energy and speed and mass. Then, graph the relationships.

Scenario 1: (Kinetic Energy & Speed; Mass remains constant)

John weighs 75 kg and wants to see how the kinetic energy changes as he rides his bike at different speeds. Analyze the data below that John collected from six different trials. Then, graph the data to the right of the chart (speed = x axis; Kinetic Energy = y axis).

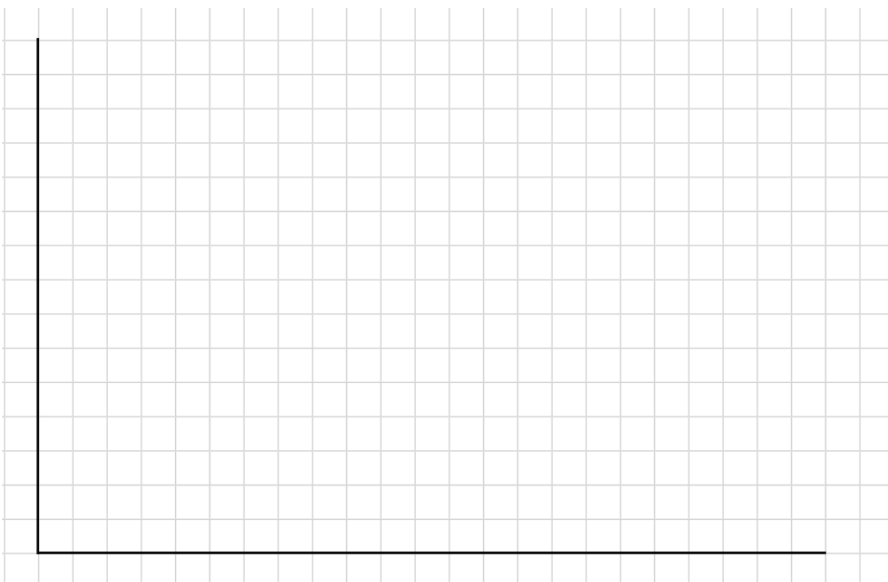
Trial	Speed (m/s)	Kinetic Energy (J)
1	0	0
2	2	150
3	4	600
4	6	1350
5	10	3750
6	13	6337.5



Scenario 2: (Kinetic Energy & Mass; Speed remains constant)

John now wants to figure out how the kinetic energy will change as the mass of an object changes. So, John rolls five different sized rocks down the same hill. Assume that the speed remains constant (2 m/s). First, analyze the data in the chart; then, graph the data. (mass = x axis; Kinetic Energy = y axis).

Trial	Mass (Kg)	Kinetic Energy (J)
1	2	4
2	5	10
3	8	16
4	15	30
5	23	46



2. Based on your graphs, how does the kinetic energy change if the mass of the object increases or decreases?
 - a. Claim:

- b. What evidence do you have from your graph(s) to support your claim?

6. John's friend, Marc, wants to test John's theory about kinetic energy and speed. Marc has a mass of 85 kg. Would you expect Marc's graph of kinetic energy vs. speed to look similar to that of John's? Why or why not? Use evidence from the graph to support your answer.

Kinetic Energy Assessment

Key and Scoring Guide

1. John is curious about how kinetic energy relates to both speed and mass. Read each scenario below about how John learns the relationships between kinetic energy and speed and mass. Then, graph the relationships.

Scenario 1: (Kinetic Energy & Speed; Mass remains constant)

John weighs 75 kg and wants to see how the kinetic energy changes as he rides his bike at different speeds. Analyze the data below that John collected from six different trials. Then, graph the data to the right of the chart (speed = x axis; Kinetic Energy = y axis).

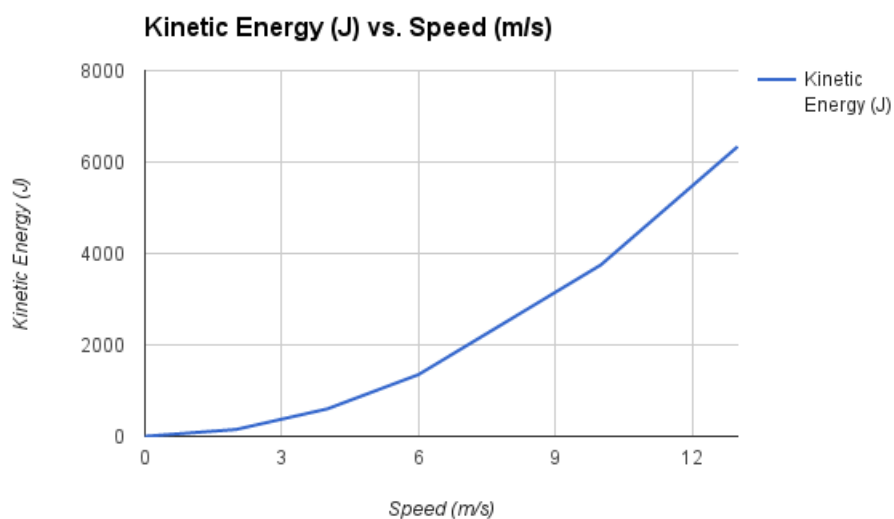
Trial	Speed (m/s)	Kinetic Energy (J)
1	0	0
2	2	150
3	4	600
4	6	1350
5	10	3750
6	13	6337.5

Scoring:

2 pts: axes are labeled correctly

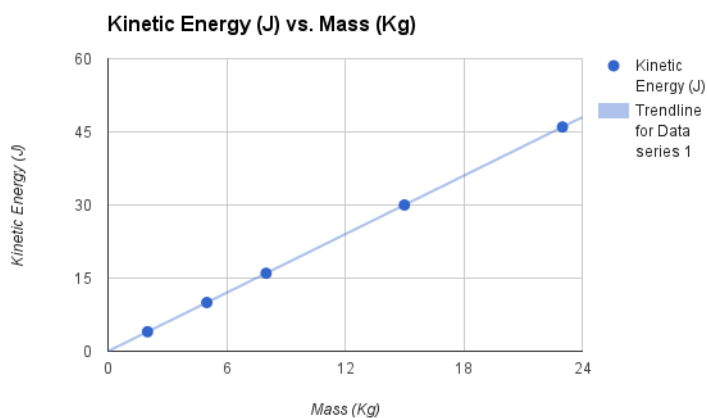
1 pt: appropriate scaling

3 pts: data is graphed correctly



Scenario 2: (Kinetic Energy & Mass; Speed remains constant)

John now wants to figure out how the kinetic energy will change as the mass of an object changes. So, John rolls five different sized rocks down the same hill. Assume that the speed remains constant (2 m/s). First, analyze the data in the chart; then, graph the data. (mass = x axis; Kinetic Energy = y axis).



Trial	Mass (Kg)	Kinetic Energy (J)
1	2	4
2	5	10
3	8	16
4	15	30
5	23	46

Scoring:

2 pts: axes are labeled correctly

1 pt: appropriate scaling

3 pts: data is graphed correctly

2. Based on your graphs, how does the kinetic energy change if the mass of the object increases or decreases?

a. Claim:

The kinetic energy will increase when the mass of the object increases.

(1 pt= kinetic energy increases; 1 pt = mass increases OR vice versa)

- b. What evidence do you have from your graph(s) to support your claim?

When looking at the Kinetic Energy vs. Mass graph, the slope of the line is positive (or the line moves upward) as the mass increases.

(1 pt= mention Kinetic energy vs. mass graph; 1 pt= correctly discusses slope or trend in the data)

3. Based on your graphs, how does the kinetic energy change if the speed of the object increases or decreases?

a. Claim:

The kinetic energy will increase as the speed of the object increases.

(1 pt= Kinetic Energy increases; 1 pt= speed increases OR vice versa)

- b. What evidence do you have from your graph(s) to support your claim?

When analyzing at the Kinetic Energy vs. Speed graph, the slope of the line is positive (or the line moves upward) as the mass increases.

(1 pt= mention Kinetic Energy vs. Speed graph; 1 pt= correctly discusses slope or trend in the data)

4. A. Based on Scenario 1 only, which of the following best describes how kinetic energy is related to the speed of the object? (Circle the correct answer.)

- a. The relationship between kinetic energy and speed is linear.
b. The relationship between kinetic energy and speed is nonlinear.

(1 pt= selects B)

- B. Explain your answer:

The relationship is nonlinear because you cannot make a straight line of best fit for the data.

(1 pt= uses the data to correctly explain why it is nonlinear)

5. A. Based on Scenario 2 only, which of the following best describes how the kinetic energy changes as the mass of the object changes? (Circle the correct answer.)

- a. The kinetic energy doubles as the mass of the object doubles.**
 b. The kinetic energy triples as the mass of the object doubles.
 c. The kinetic energy quadruples as the mass of the object doubles.
 d. The kinetic energy halves as the mass of the object doubles.

(1 pt = selects A)

- B. Explain your answer:

For each mass data point, the kinetic energy is twice as much as the mass.

(2 pts = correctly uses mass and kinetic energy to show the kinetic energy doubles)

6. John's friend, Marc, wants to test John's theory about kinetic energy and speed. Marc has a mass of 85 kg. Would you expect Marc's graph of kinetic energy vs. speed to look similar to that of John's? Why or why not? Use evidence from the graph to support your answer.

Marc's graph of kinetic energy vs. speed should look similar to John's since Marc's mass is not changing.

(1 pt= looks similar; 2 pts= uses data OR the graph to explain that Marc's mass would not change so the graph should be similar to that of John's)

Scoring Suggestion: 28 Total Points

Authentic Assessment Checklist: Kinetic Energy

- The student creates/applies their own learning.
- The student uses tools, skills, knowledge needed beyond school.
- The student produces a high quality product that has more than one possible answer.
- The student must defend their answer(s).
- The students collaborate with each other or the teacher.
- The student can demonstrate knowledge or skills through more than one way.
- The task relates to the field of science and/or engineering.
- The task is directly correlated to the targeted NGSS performance standard.
- The task incorporates multiple Science and Engineering Practices as outlined by the
NGSS standards
- Asking Questions/Defining Problems
 - Developing & Using Models
 - Planning & Carrying Out Investigations
 - Analyzing & Interpreting Data
 - Using Math/Computational Thinking
 - Constructing Explanations
 - Engaging in Argument from Evidence
 - Obtain, Evaluating, & Communicating Information
- The task incorporates multiple levels of Bloom's Taxonomy and includes Creating and/or
Evaluating
- Remembering
 - Understanding

Applying

Analyzing

Evaluating

Creating

Assessment #3: Atoms and Molecules

Possible Unit Outline: This type of a unit may begin with the study and investigation of matter and its stages, solids, liquids, and gases. Students then can investigate what matter is made of (atoms) and how those atoms make-up simple and complex molecules. Students can then work through an activity where they determine the relationship between atomic number, mass, neutrons, electrons, protons, and the number of energy levels an atom has. Students should also investigate how the atoms and molecules are held together through atomic bonds. Once students have this understanding they should be ready for the assessment.

Key Unit Vocabulary: matter, solid, liquid, gas, atom, ionic compound, molecule, bond, protons, neutrons, electrons, energy levels (orbitals), atomic mass, and atomic number.

NGSS Assessment Teacher Pages

Atoms and Molecules Assessment

Next Generation Science Standards Performance Expectation(s):

MS-PS1-1: Develop models to describe the atomic composition of simple molecules and complex structures.

Time-Frame: Approximately three, 45 minute class periods.

Assessment Overview:

This assessment is written for students to demonstrate their understanding of atomic structure and how atoms can bond to form ionic compounds, simple molecules and more complex structures. The assessment is written as a presentation project for a team of two students. This could easily be altered for one student if preferred by the teacher. Once

students create a presentation and make their basic models, they are required to record themselves giving the presentation so they can show how the molecule is formed while they explain it at the same time.

Materials Needed:

- Atoms and Molecules assessment student pages
- Access to slideshow software (Powerpoint or Google slides)
- Access to recording software/app/extension (this assessment suggests "Screencastify" which is a Google Extension)
- Ionic Compound and Molecule cards
- Access to atomic models (the students can use actual atom/molecule kits that can be purchased from a lab equipment company or something as simple as marshmallows, gumdrops, and toothpicks to create their models)

Directions for Administering the Assessment:

1. Go through the steps of the project with students.
2. Have students pick partners and pick their ionic compound and molecule cards (each pair of students needs one of each type of card).
3. On Day 2: briefly show students how to use the recording software or extension

Student Pages (actual assessment):

Atoms and Molecules Assessment

In a team of two, create a presentation (10 minutes max) that shows how atoms combine to make ionic compounds and molecules (you will be given two different structures that are pure substances). Using the Google extension "screencastify", record yourself giving your presentation and showing how you created the model of your molecules.

For BOTH molecules include:

1. **Background Information:** Include general information about your ionic compound and molecule: chemical formula, name, picture (how it looks normally), and a description of the pure substance. Any information taken from another resource should be cited.
2. **Model of Atoms:** A model you created of each individual atom (include protons, neutrons, electrons and energy levels).
3. **Model of Structure:** A model that you created for the ionic compound and molecule. You may use the "Chem Kits Models" in the classroom or anything else that could be used to represent atoms and bonds to form the molecule. During your presentation, show how the atoms bond together to form the molecule. (So, show the connections each atom would make to each other to form the molecule.)

4. **Atom, Molecule, and Bond:** What parts are the individual atoms, what parts are the “bonds”, and what part is the compound or molecule? Describe this in your presentation.

After you have done steps 1-4 for both molecules:

5. **Compare/Contrast:** List at least two similarities and two differences between the two structures.
6. **References:** Include a slide that has the references for the information in your presentation.

You and your partner must take turns talking and describing BOTH molecules. (You can't just each pick one to describe.)

Scoring **Student Names** _____

Atoms and Molecules Assessment

Component	Outstanding 5 Points	Competent 4-3 Points	Sketchy 2-0 Points
Background Information	Includes the chemical name, formula, picture and one more piece of information for both molecules.	Only includes the chemical name, formula, and picture for both molecules.	Missing the chemical name or formula for one or both molecules.
Model of Atoms	All atoms are modeled correctly showing the correct number and placement of protons, neutrons, electrons and energy levels.	One atom has incorrect information.	Two or more atoms have incorrect information.
Model of Molecules	Correctly shows the structure of both the ionic compound and molecule AND describes/shows how the molecules are formed.	Incorrectly shows the structure OR the process of how ONE of the compound/molecule is formed.	Incorrectly shows the structure OR the process of how BOTH compounds/molecules are formed.
Atom, Ionic Compound, Molecule, and Bond	Correctly uses the terms atom, bond, ionic compound, and molecule.	Incorrectly describes an atom, bond, ionic compound, or molecule for one of the structures.	Incorrectly describes an atom, bond, ionic compound, or molecule for both of the structures.

Compare & Contrast	Correctly includes two similarities and two differences between both structures.	Includes only one correct similarity and difference.	The similarities and differences describes are vague OR is not included.
Presentation Quality	The presentation flows easily. There is evidence that presenters have created a high quality presentation. The presenters share equal work. References slide is included.	The presentation could use work or the presenters need more rehearsal for their presentation.	The presentation is missing too many pieces and/or there is little evidence that the presenters have created a high quality presentation. The presentation is not submitted on time. Reference slide is not included.
_____ / 30 Total Points			

Ionic Compound	Molecule
Calcium chloride	Diamond
Sodium sulfide	Graphite
Lithium sulfide	Sugar
Barium oxide	Hydrogen peroxide
Potassium sulfide	Flour (C ₄ H ₈ O ₄)
Calcium oxide	Water
Lithium iodide	Ammonia
Magnesium chloride	Methane

Magnesium iodide	Sulfur dioxide
Potassium chloride	Nitric oxide
Potassium iodide	Nitrous oxide
Potassium oxide	Carbon dioxide
	Carbon chloride

Authentic Assessment Checklist: Atoms and Molecules

- The student creates/applies their own learning.
- The student uses tools, skills, knowledge needed beyond school.
- The student produces a high quality product that has more than one possible answer.
- The student must defend their answer(s).
- The students collaborate with each other or the teacher.
- The student can demonstrate knowledge or skills through more than one way.
- The task relates to the field of science and/or engineering.
- The task is directly correlated to the targeted NGSS performance standard.
- The task incorporates multiple Science and Engineering Practices as outlined by the NGSS standards
- Asking Questions/Defining Problems
- Developing & Using Models
- Planning & Carrying Out Investigations
- Analyzing & Interpreting Data

- Using Math/Computational Thinking
- Constructing Explanations
- Engaging in Argument from Evidence
- Obtain, Evaluating, & Communicating Information
- The task incorporates multiple levels of Bloom's Taxonomy and includes Creating and/or Evaluating
 - Remembering
 - Understanding
 - Applying
 - Analyzing
 - Evaluating
 - Creating

Assessment #4: Molecules and States of Matter

Possible Unit Outline: Students should already have a background of the atom and how atoms make-up molecules. From there the unit can begin with states of matter and how atoms and molecules “act” at each different state of matter. There are many online simulations that can help show this concept. The unit should continue where students investigate how the conduction of heat energy changes the temperature and state (phase change) of matter. This concept can be taught using an inquiry investigation. Either through group work or direct instruction students should be able to understand and explain the boiling point and melting/freezing point of substances.

Key Unit Vocabulary: melting/freezing point, boiling point, phase change, state, solid, liquid, gas, atom, molecule, kinetic energy, thermal energy, temperature, evaporation, condensation, boiling, freezing, melting, model, and pure substance.

NGSS Assessment Teacher Pages

Molecules & States of Matter Assessment

Next Generation Science Standards Performance Expectation(s):

MS-PS1-4: Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.

Assessment Overview:

The assessment will assess student's knowledge of molecules, states of matter, and how the motion, spacing and energy changes among states of matter. Students need to have a basic understanding of chemical formulas in order to accurately complete the assessment.

Materials Needed:

- Student assessment pages
- Materials for chart assessment (circles, arrows, state cards, etc.)

Directions for Administering the Assessment:

1. Hand-out the student assessment pages.
2. Discuss with students each step (first page) and the chart found on the second page of the assessment.
3. Answer any student questions about the steps and/or chart.
4. Hand-out one pure substance card to each student. The pure substances can be differentiated so lower level students have simpler molecules and the higher level students have more complex molecules.
5. Allow students to complete the assessment.

Scoring:**Rubric**

Component	Outstanding	Building	Sketchy
Labeling the Chart	<p>Student correctly labels the following (each is 2 points):</p> <ul style="list-style-type: none"> -melting/freezing pt -boiling pt -solid -liquid -gas -increase kinetic energy -increase thermal energy -phase change evaporation -phase change melting -phase change condensation 	Student incorrectly labels 2-3 components.	Student incorrectly labels 4+ components.
Model	Student correctly models each substance by showing the: 1) correct change of motion, 2) correct change of spacing/attraction and 3) the same number of molecules in each jar.	Student correctly models each substance by showing all BUT ONE of the following: 1) correct change of motion, 2) correct change of spacing/attraction and 3) the same number of molecules in each jar.	Student either incorrectly models each substance or correctly models each substance by demonstrating ONLY ONE of the following: 1) correct change of motion, 2) correct change of spacing/attraction and 3) the same number of molecules in each jar.
Kinetic Energy (Q1)	Correctly describes how the kinetic energy changes from a solid to a liquid to a gas.		Incorrectly describes the change in kinetic energy.
Thermal Energy (Q2&3)	<p>Student correctly identifies all states as having thermal energy.</p> <p>Correctly describes how to change the rate of thermal energy.</p>	The technique described to increase the rate of thermal energy applied is not correct.	<p>Incorrectly describes all states as having thermal energy.</p> <p>Incorrectly describes how to change the pure substance from a liquid to a solid.</p> <p>Provides an incorrect answer of how to increase the rate of the phase change.</p>

Using the Chart (Q4)	Student correctly identifies the states as "liquid".		Student incorrectly identifies the state.
Conduction (Q5)	Correctly uses the words heat, conduction, kinetic energy, and molecules to describe the change in energy. Correctly describes the direction of energy.	Incorrectly uses one word to describe the transfer of energy. Incorrectly or does not describe the direction of conduction.	Incorrectly uses two or more words in describing the transfer of energy. Incorrectly or does not describe the direction of conduction.

Student Pages (Actual Assessment):

Student Name _____ Hour _____ Date _____

Molecules & States of Matter Assessment

PART 1: Molecules and States of Matter Chart

You will be using circles as molecules and lines to show motion to create a model for **acetone** as a solid, liquid, and gas in the closed bottles shown on your "MODEL CHART" page. Pretend you are making a model of the same bottle as you are just adding or removing thermal energy to change the state of acetone. You take a picture of the bottle (at the molecular level) at three different times (solid, liquid, gas).

The melting/freezing point for acetone is $-95\text{ }^{\circ}\text{C}$. The boiling point is $57\text{ }^{\circ}\text{C}$.

You are given numerous arrows, words, and circles (molecules). Your goal is to paste these to your orange "MODEL CHART" to create a diagram that shows how energy and states of matter changes. You may need to draw on each model to really show the big ideas.

PART 2: Molecules and States of Matter Test Questions

Use your chart (orange paper) to answer questions #1-5.

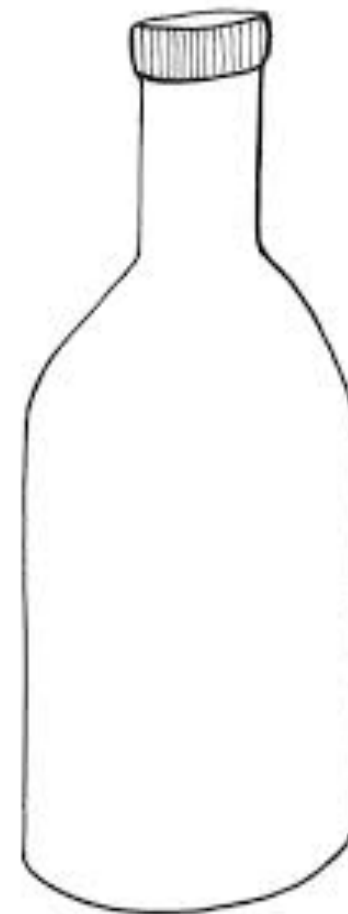
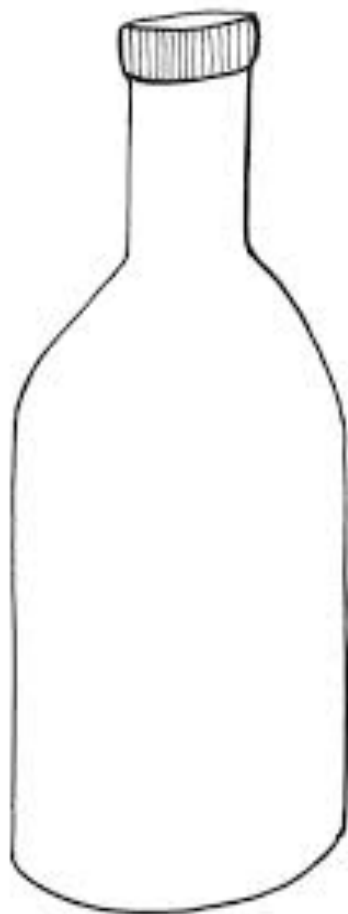
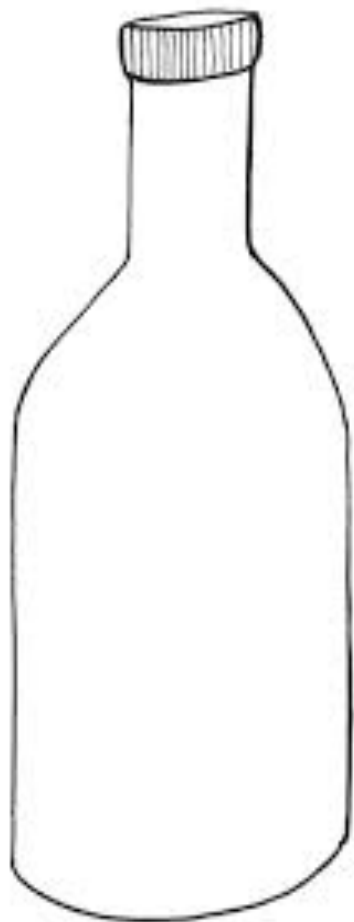
1. Describe how the kinetic energy of the acetone molecules changes in going from a solid to a liquid to a gas. [2 points]

2. In which states (solid, liquid, and/or gas) does acetone have thermal energy? Defend your answer. [2 points]

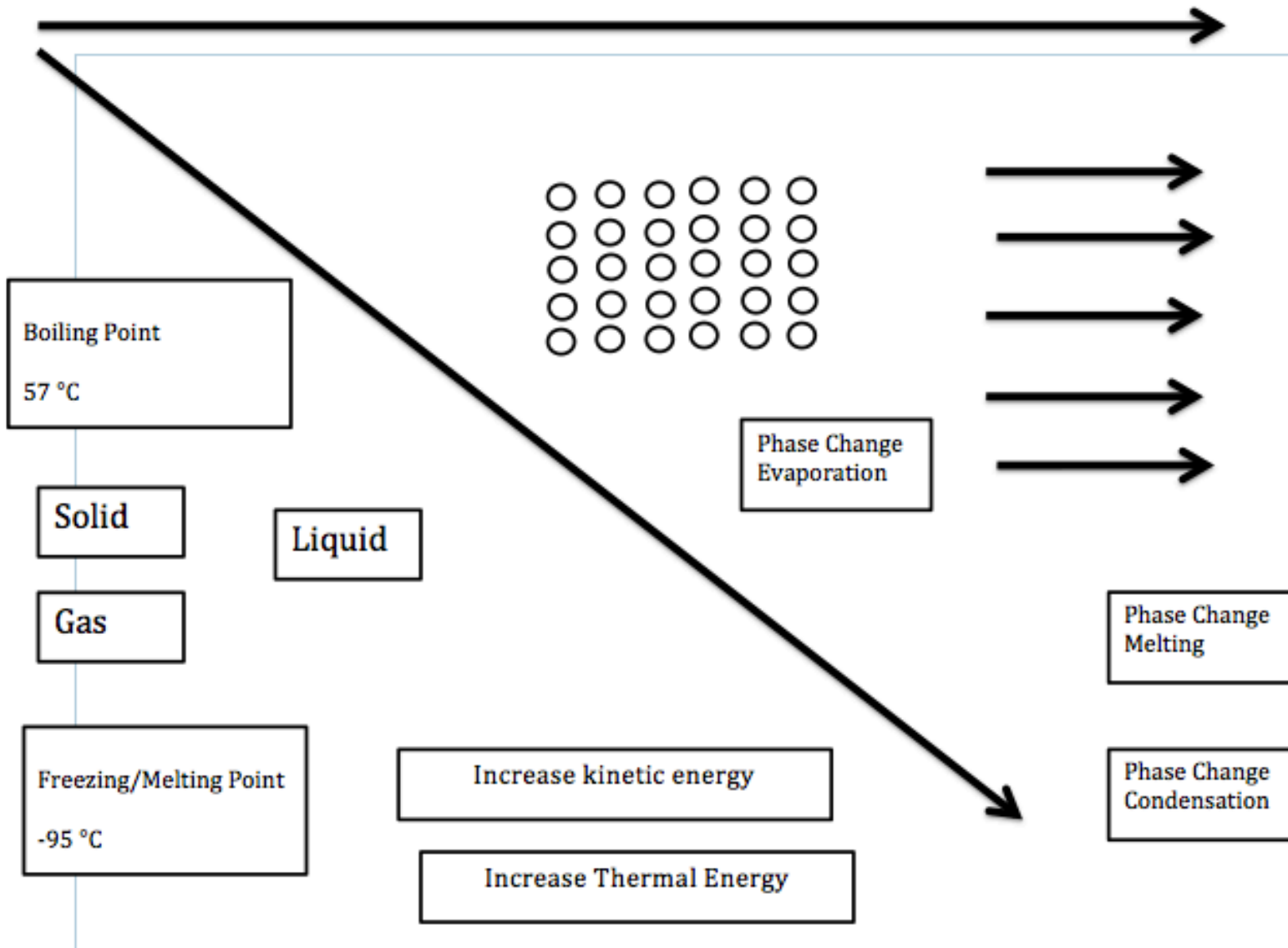
3. If you wanted to change acetone from a solid to a liquid, would you add or remove thermal energy? How could you increase the rate of changing your substance from a solid to a liquid? [2 points]

4. A warm sunny day is about 25 °C. At what state is acetone at this temperature? How can you tell? [2 point]

5. If you added a piece of ice to acetone when it is in a liquid state, describe how the transfer of thermal energy would occur between the ice and acetone (assume the acetone **is -20 °C** and the ice **is 0 °C**)? Use the words conduction, kinetic energy, temperature, and molecules in your answer. [4 points]



Materials for students to complete the “Model Chart”



Molecules & States of Matter Assessment

Key

PART 1: Molecules and States of Matter Chart

You will be using circles as molecules and lines to show motion to create a model for **acetone** as a solid, liquid, and gas in the closed bottles shown on your “MODEL CHART” page. Pretend you are making a model of the same bottle as you are just adding or removing thermal energy to change the state of acetone. You take a picture of the bottle (at the molecular level) at three different times (solid, liquid, gas).

The melting/freezing point for acetone is $-95\text{ }^{\circ}\text{C}$. The boiling point is $57\text{ }^{\circ}\text{C}$.

You are given numerous arrows, words, and circles (molecules). Your goal is to paste these to your orange “MODEL CHART” to create a diagram that shows how energy and states of matter changes. You may need to draw on each model to really show the big ideas.

PART 2: Molecules and States of Matter Test Questions

Use your chart (orange paper) to answer questions #1-5.

1. Describe how the kinetic energy of the acetone molecules changes in going from a solid to a liquid to a gas. [2 points]

As the substance changes from a solid to liquid to a gas, the kinetic energy increases.

2. In which states (solid, liquid, and/or gas) does acetone have thermal energy? Defend your answer. [2 points]

1pt= All states have thermal energy

1pt= All states have thermal energy because the molecules have kinetic energy or the molecules are in motion.

3. If you wanted to change acetone from a solid to a liquid, would you add or remove thermal energy? How could you increase the rate of changing your substance from a solid to a liquid? [2 points]

Thermal energy must be added. To change the rate you simply must add more thermal energy. For example, putting the bottles in boiling water (i.e. $100\text{ }^{\circ}\text{C}$) would change the rate faster than putting the bottles in warm water ($50\text{ }^{\circ}\text{C}$).

4. A warm sunny day is about 25 °C. At what state is acetone at this temperature? How can you tell? [2 point]

Acetone is in a liquid state. You can tell because 25 °C is in between the melting/freezing point and boiling point for acetone.

5. If you added a piece of ice to acetone when it is in a liquid state, describe how the transfer of thermal energy would occur between the ice and acetone (assume the acetone is -20 °C and the ice is 0 °C)? Use the words conduction, kinetic energy, temperature, and molecules in your answer. [4 points]

Thermal energy would occur between the ice to the acetone since the ice is at a higher temperature than the acetone. The kinetic energy of the molecules for the acetone would increase and so would the temperature.

Authentic Assessment Checklist: Molecules & States of Matter

- The student creates/applies their own learning.
- The student uses tools, skills, knowledge needed beyond school.
- The student produces a high quality product that has more than one possible answer.
- The student must defend their answer(s).
- The students collaborate with each other or the teacher.
- The student can demonstrate knowledge or skills through more than one way.
- The task relates to the field of science and/or engineering.
- The task is directly correlated to the targeted NGSS performance standard.
- The task incorporates multiple Science and Engineering Practices as outlined by the NGSS standards
- Asking Questions/Defining Problems

- Developing & Using Models
 - Planning & Carrying Out Investigations
 - Analyzing & Interpreting Data
 - Using Math/Computational Thinking
 - Constructing Explanations
 - Engaging in Argument from Evidence
 - Obtain, Evaluating, & Communicating Information
- The task incorporates multiple levels of Bloom's Taxonomy and includes Creating and/or Evaluating
- Remembering
 - Understanding
 - Applying
 - Analyzing
 - Evaluating
 - Creating

Assessment #5: Motion and Stability: Forces and Interactions

Possible Unit Outline: This assessment will assess the scientific practice of planning an investigation. Therefore, it may be done more at the start of the unit and the disciplinary core ideas will be instructed after the assessment. However, for students to be able to develop an investigation they must have had practice developing an investigation in the past. They also should understand fair test, independent, dependent, and control variables. These concepts could

have been taught in prior units and are also part of the NGSS standards for grades 3-5. Students should have already investigated mass and forces in order to complete the assessment.

Key Unit Vocabulary: mass, forces, sum of forces, balanced forces, unbalanced forces, fair test, control variable, dependent variable, independent variable, and procedure.

NGSS Assessment Teacher Pages

Motion & Stability: Forces & Interactions

Assessment

Next Generation Science Standards Performance Expectation(s):

MS-PS2-2: Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.

Assessment Overview:

This assessment will test students' scientific practice knowledge of designing a controlled investigation along with their understanding of motion and forces. Students will work in small teams (recommendation: 3-4 students per team) to develop a procedure for their investigation. The assessment would be appropriate to be used towards the middle of a unit on forces, as students do not have to collect data to complete the assessment. The next part of the unit could involve students running their procedure and collecting data.

Materials Needed:

- Student assessment page
 - Access to technology for word processing
- Per Group:*
- 3 toy cars of different masses OR 3 toy cars of the same mass with the ability to attach different masses
 - Ramp (you are able to change the angle/height of the ramp)
 - Scale
 - Ruler
 - Stopwatch

Directions for Administering the Assessment:

On the first day, hand out the student assessment page and read through it with the class. Show them the materials they will be able to use. Even though they do not have to actually collect data to complete the assessment, it would still be beneficial for students to see and even manipulate some of the materials in order to write a solid procedure. Once students

have an understanding for their task, assign teams of 3-4 members to complete the assessment. The assessment should take approximately two, 45-minute class periods to complete successfully.

Scoring:

Component	Outstanding	Building	Sketchy
Purpose	The team lists each purpose (a-c; as stated in the "Procedure section of the student pages) at the start of their procedure.	The team lists some components of the purpose but some are vague or are inaccurate.	The purpose statements are missing.
Variables	The procedures are a fair test in that appropriate factors are held constant; independent variables (mass, angle of ramp, friction) are correctly identified and tested one at a time. The independent variables are the forces acting on the object and the mass of the object. The dependent variable is identified as the motion of the object.	One or two of the control variables are missing. One of the independent or dependent variables is missing or incorrectly identified.	Three or more of the control variables are missing. AND The independent and/or dependent variables are incorrectly identified.
Procedure	The procedure is well written in chronological order. It includes how the team will keep the control variables constant, change the independent variables one at a time, and measure the dependent variables. The team sufficiently describes how they will	The procedure is written in chronological order. It includes how the team will keep the control variables constant, change the independent variables, and measure the dependent variables but 1-2 important details are missing. The team describes how they will measure motion, mass	The procedure is written. There is little to no details on how the team will keep the control variables constant, change the independent variables, and measure the dependent variables. The team rarely mentions how they will measure motion, mass

	determine and measure motion, mass, and forces using correct techniques and units. Another lab team could easily replicate the procedure.	and forces but some techniques are vague or units are incorrect. Another lab team could complete the procedure but would have questions about certain steps.	and forces. Their techniques and/or units are inaccurate. Another lab team would have difficulty completing the procedure.
Data	Tables show an efficient way to collect the following data: <ul style="list-style-type: none"> • Motion • Total forces acting on the object • Mass of the object Tables show the number of trials and averages.	Tables have a way to collect the following data: <ul style="list-style-type: none"> • Motion • Total forces acting on the object • Mass of the object Tables do not show the number of trials.	Tables are missing data collection for one of the three data types. Tables do not show the number of trials.
Ready to Analyze	The team correctly shows what data is needed to prove: <ol style="list-style-type: none"> 1) an object with balanced forces does not change its motion, 2) object with unbalanced forces changes its motion over time, 3) the change in motion of an object with unbalanced forces depends on the mass of the object and the how unbalanced the forces are acting on the object. 	The team correctly shows what data is needed to prove ONLY TWO of the three settings: <ol style="list-style-type: none"> 1) an object with balanced forces does not change its motion, 2) object with unbalanced forces changes its motion over time, 3) the change in motion of an object with unbalanced forces depends on the mass of the object and the how unbalanced the forces are acting on the object. 	The team incorrectly shows what data is needed to prove or correctly shows ONLY ONE of the three settings: <ol style="list-style-type: none"> 1) an object with balanced forces does not change its motion, 2) object with unbalanced forces changes its motion over time, 3) the change in motion of an object with unbalanced forces depends on the mass of the object and the how unbalanced the forces are acting on the object.

Student Pages (Actual Assessment):

Motion & Stability: Forces & Interactions

Assessment

Task: You and your team will plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.

Materials available to use:

- 3 toy cars of different masses OR 3 toy cars of the same mass with the ability to add different masses to them (your choice)
- Ramp (you are able to change the angle/height of the ramp)
- Scale
- Ruler
- Stopwatch

Your plan should be typed, printed, and include the following components:

- 1) **Purpose:** The purpose of your procedure is to prove that:
 - a. An object influenced by balanced forces does not change its motion.
 - b. An object influenced by unbalanced forces changes its motion over time.
 - c. The change in motion of an object influenced by unbalanced forces depends on the mass of the object.
- 2) **Variables:** Include a list of control, independent, and dependent variables.
- 3) **Procedure:** List steps on how you will collect data. Your procedure should be so well written that if it was given to another lab team, they would be able to do everything exactly the same way you did and collect the same data. Also, make sure you describe how you will keep the control variables constant, change the independent variable(s), and measure the dependent variable.
- 4) **Data tables:** Include data tables (with names or numbers to be referenced later) for the data to be collected. Please refer back to your purpose so you know what data to collect. Also, consider the number of trials you must complete to have "acceptable" data. Your data tables should have space for the number of trials needed.
- 5) **Ready to Analyze:** Go back to your purpose and describe which specific data tables you will use to prove each part (a-c) of the purpose for your procedure.

Authentic Assessment Checklist: Motion & Stability: Forces & Interactions

The student creates/applies their own learning.

The student uses tools, skills, knowledge needed beyond school.

The student produces a high quality product that has more than one possible answer.

- The student must defend their answer(s).
- The students collaborate with each other or the teacher.
- The student can demonstrate knowledge or skills through more than one way.
- The task relates to the field of science and/or engineering.
- The task is directly correlated to the targeted NGSS performance standard.
- The task incorporates multiple Science and Engineering Practices as outlined by the NGSS standards
- Asking Questions/Defining Problems
 - Developing & Using Models
 - Planning & Carrying Out Investigations
 - Analyzing & Interpreting Data
 - Using Math/Computational Thinking
 - Constructing Explanations
 - Engaging in Argument from Evidence
 - Obtain, Evaluating, & Communicating Information
- The task incorporates multiple levels of Bloom's Taxonomy and includes Creating and/or Evaluating
- Remembering
 - Understanding
 - Applying
 - Analyzing
 - Evaluating
 - Creating

Assessment #6: Synthetic Materials

Possible Unit Outline: This unit should start with an investigation of what synthetic products are so students understand many of the general things they use and/or eat can be a synthetic material. From there, students should complete an investigation that shows how a synthetic resource can be made from a natural resource. The American Chemical Society, “Middle School Chemistry” (2016) has a lesson plan called “Natural Resources and Synthetic Materials”. This lesson plan has students experimenting with sodium alginate and calcium chloride to make gel worms. This experiment will allow students to build the background knowledge needed to complete the research assessment. Once students have a basic understanding of synthetic materials, it would also be necessary to discuss credible sources and bias as this is a primary component of the assessment.

Key Unit Vocabulary: synthetic materials, natural resource, credible source, bias,

NGSS Assessment Teacher Pages

Synthetic Materials Assessment

Next Generation Science Standards Performance Expectation(s):

MS-PS1-3: Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.

Assessment Overview:

This assessment is incorporated to test students’ knowledge of the production of synthetic materials and also have them analyze two sources based upon bias and credibility.

Materials Needed:

- Two credible sources about the same synthetic material
- Student Assessment pages
- Access and time for students to complete the “sharing” part of the assessment

Directions for administering the assessment:

On the first day, discuss the student pages for the assessment and allow students to begin finding credible sources (articles or videos) that include the information needed. To

differentiate this assessment, it is okay to provide two sources for some students. As the teacher, it may be necessary to okay the sources before the student proceeds with part 2. This will help ensure the level of the source is appropriate for the student. Advanced students may need to select higher levels of sources. Once students have both sources, they may begin part 2 which will help them compare each source. This will lead students into part 3 where they will create a way to share their learning. The main scoring for the assessment comes from the sharing creation projection of part 3.

Scoring:

Component	Outstanding	Building	Sketchy
Background Information	Includes name and how the synthetic material is produced.	Includes the name and how the synthetic material is produced but is missing the resources it comes from.	Includes the name but the description on how the synthetic material is produced is inaccurate or too vague.
Compare / Contrast of Properties	Adequately compares / contrasts chemical and physical properties of the synthetic material and the natural resource.	Compares / Contrasts chemical and physical properties of the synthetic material and the natural resource.	The comparison is limited and only includes similarities or differences, not both.
Need	Adequately describes the need the synthetic material will fulfill.		Does not describe the need the synthetic material will fulfill.
Impact	Describes how the natural resources will be impacted from the production of the synthetic material.	Does little to describe the impact on the natural resources.	Does not describe the impact on the natural resources.
Bias & Credibility	Adequately describes the meaning and learning of bias and credibility. There is evidence that the student analyzed both sources to determine bias and credibility.	Adequately describes the meaning and learning of bias and credibility. There is limited evidence that the student analyzed both sources to determine bias and credibility.	Vaguely describes the meaning and learning of bias and credibility. There is no evidence that the student analyzed both sources to determine bias and credibility.
Overall Quality	The project is organized and its implementation is well put together.	The project is organized but could be put together better.	The project is not organized. There are many

	There are limited grammatical errors to distract from the content.	There are some grammatical errors.	grammatical errors.
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Student Pages (Actual Assessment):

Synthetic Materials Assessment

Part 1: Gather Information

Your task is to find information from two credible sources (articles, videos, graphs, etc.) that describes the following:

- A) How the synthetic material is produced (include from what natural resource(s))
- B) The need the synthetic material fulfills within society

Part 2: Analysis

Answer the following questions to help you analyze your two sources about the synthetic material.

1. What is the synthetic material being produced?

2. Name of First Source: _____
 Evaluate the credibility of this source:
 - a. Does there seem to be bias? What evidence do you have to support your answer?

 - b. Does the source seem to be credible? What evidence do you have to support your answer?

 - c. Does the source seem to be credible? What evidence do you have to support your answer?

7. Why is there a need for this synthetic material in our society?

8. How does the production of this synthetic material effect natural resource(s)?

Part 3: Sharing

Develop a way to share the information included below to your classmates. Some ideas may include: visual display (poster or trifold), slideshow, flyer, screencast, diorama, or any other idea that is okayed by your teacher.

What must be included?

- Name of the synthetic material
- How the synthetic material is produced (what resources does it come from)
- Compare/Contrast of the properties from the synthetic materials to those of the natural resource(s) it is produced from
- Need for the synthetic material
- Impact on natural resources
- What you learned about bias and credibility by analyzing the two sources you selected.

Scoring:

Component	Outstanding	Building	Sketchy
Background Information	Includes name and how the synthetic material is produced.	Includes the name and how the synthetic material is produced but is missing the resources it comes from.	Includes the name but the description on how the synthetic material is produced is inaccurate or too vague.
Compare / Contrast of Properties	Adequately compares / contrasts chemical and physical properties of the synthetic material and the natural resource.	Compares / Contrasts chemical and physical properties of the synthetic material and the natural resource.	The comparison is limited and only includes similarities or differences, not both.
Need	Adequately describes the need the synthetic material will fulfill.		Does not describe the need the synthetic material will fulfill.
Impact	Describes how the natural resources will be impacted from the production of the	Does little to describe the impact on the natural resources.	Does not describe the impact on the natural resources.

	synthetic material.		
Bias & Credibility	Adequately describes the meaning and learning of bias and credibility. There is evidence that the student analyzed both sources to determine bias and credibility.	Adequately describes the meaning and learning of bias and credibility. There is limited evidence that the student analyzed both sources to determine bias and credibility.	Vaguely describes the meaning and learning of bias and credibility. There is no evidence that the student analyzed both sources to determine bias and credibility.
Overall Quality	The project is organized and its implementation is well put together. There are limited grammatical errors to distract from the content.	The project is organized but could be put together better. There are some grammatical errors.	The project is not organized. There are many grammatical errors.

Authentic Assessment Checklist: Synthetic Materials

- The student creates/applies their own learning.
- The student uses tools, skills, knowledge needed beyond school.
- The student produces a high quality product that has more than one possible answer.
- The student must defend their answer(s).
- The students collaborate with each other or the teacher.
- The student can demonstrate knowledge or skills through more than one way.
- The task relates to the field of science and/or engineering.
- The task is directly correlated to the targeted NGSS performance standard.
- The task incorporates multiple Science and Engineering Practices as outlined by the NGSS standards
- Asking Questions/Defining Problems
- Developing & Using Models

- Planning & Carrying Out Investigations
- Analyzing & Interpreting Data
- Using Math/Computational Thinking
- Constructing Explanations
- Engaging in Argument from Evidence
- Obtain, Evaluating, & Communicating Information
- The task incorporates multiple levels of Bloom's Taxonomy and includes Creating and/or Evaluating
 - Remembering
 - Understanding
 - Applying
 - Analyzing
 - Evaluating
 - Creating

Chapter 4: Reflection

This project has had a major impact on the structure of my assessments and even my instruction. My project included the creation six major assessments targeted to the NGSS standards. However, I have also altered other assessments I currently administer within my classroom to include more authentic components. Because of this, my assessments now not only assess recall information, but all of my assessments incorporate higher order thinking from Bloom's Taxonomy. This allows students to develop more critical thinking skills and demonstrate higher order thinking skills with their assessments.

The project can be extended (and will be extended) as my district continues the process of fully adopting and implementing the NGSS standards. As more standards are implemented in my classroom, I will need to write more authentic assessments that are targeted towards my specific curriculum standards. Some assessments may need to be revised to best fit the classroom or student needs once they have been implemented.

This project has led in my professional growth, as I have had to become better versed in the NGSS standards. Writing the assessments, I required a deep understanding of the content that the assessment is targeted towards. Along with that, I have also learned there are some standards which lend themselves to be more authentic tasks, as defined in the literature review, than others. Even though an assessment may be directly targeted towards an NGSS standard, it did not necessarily mean it could be rated with the most authenticity possible.

Learning about the entire context and what is meant by "performance expectations" has also been new and challenging. My definition of performance expectation as outlined by the NGSS standards has changed from the start of this project to the end of this project. At first, I would have considered a performance expectation to mean that students are completing some

type of hands-on investigation or creating a project that demonstrates learning. However, this is not necessarily the case when looking at the six assessments I created. Each assessment had a different type of performance:

- Assessment 1: Design a monitoring plan
- Assessment 2: Graph and interpret graphs
- Assessment 3: Create a model
- Assessment 4: Create a model
- Assessment 5: Plan an investigation
- Assessment 6: Research and decipher information

For these assessments, many of these “performance expectations” students complete by sitting at their seats; it is much less laboratory based than I had previously expected. Therefore, when assessing a “performance” it does not necessarily mean what one may expect.

Being able to create the authentic assessments and determine the authenticity provided me with another challenge and opportunity to learn. It was sometimes difficult to aim for some of the components of the authentic assessment checklist. For example, there were few assessments where “students collaborated with each other”. As I reflect, some of the assessments could easily be adjusted so this occurred more, but sometimes it is not possible nor desirable especially if I, the teacher, only want to assess what one individual student knows and can do. There were a few components that were quite easily targeted. For example, “the assessment related to the targeted NGSS standard” was always met because that is where the process to create each assessment began. Also, the “student creates/applies their own learning” was another component included with every assessment.

My future direction will be the completion of this project as I continue to write authentic assessments and pilot them with my students. As my classroom is currently in a change process from old curriculum standards to full implementation of the NGSS standards for 8th grade science, I will be writing many more assessments. This creative component has allowed me to learn much more about characteristics for authentic assessments and I will be able to effectively and creatively include those into my new summative assessments for my classroom.

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