SCIENCE OF THE SUMMER OLYMPICS

The Biomechanics of Usain Bolt: An Engineering Perspective

**LESSON TEMPLATE**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Grade Level: 6-12** | | | **Time for Lesson:** | |
| **Title:** The Biomechanics of Usain Bolt: An Engineering Perspective | | **Topic:** Biological Engineering | | **Focus Question:** How does a person’s body type affect their ability to do a sport? |
| **Standards:** See standards reference page | | | | |
| **Learning Target(s):** *(Big Ideas)* **Understand biomechanics through the engineering and scientific practices.** | | | | |
| **Success Criteria (Content Objectives):** *(Measurable evidence of learning; how students will demonstrate the learning; student friendly*;)  I can develop a testable question.  I can make a prediction.  I can identify controls and variables.  I can develop the procedural steps for an investigation.  I can construct a table to collect data.  I can make a claim supported with evidence.  I can develop a scientific conclusion. | | | **Success Criteria (Language Objectives):** *(Measurable evidence of learning; how students will demonstrate the learning; student friendly*;) *can include all four language modalities of reading, writing, listening and speaking)*  I can write a testable question.  I can write a prediction.  I can discuss controls and variables.  I can write out the steps for an investigation.  I can communicate a claim supported with evidence.  I can ask for feedback from my classmates.  I can communicate my scientific conclusion. | |
| **Student Engagement: Leadership Success Criteria**   * I can adapt speech when working collaboratively with my table team versus publicly presenting my findings. | | | | |
| **Key Vocabulary:**   * prediction\* * evidence\* * mechanics * stride * calculate * trial * analyze * claim * observation\* * control\* | **Lesson Supports** (for diverse learners including migrant, ELL and students with multimodal supports)  T-Chart for Social Skills Notes  Prompts  Athlete T-Chart Example  Numbered Heads Together Teacher Notes  Home School Connection Notes  Vocabulary Support Notes  Scaffolding the Inquiry Process  Teacher Rubric | | | **Materials:**   * Internet/projection equipment for online video * science notebooks * markers * tape measures * flip chart paper * Athlete picture cards * Athlete T-Chart * Home School Connection * Student Rubrics |
| **Other Vocabulary:**   1. characteristics\* 2. advantage 3. data\* 4. length 5. speed 6. compare 7. related 8. graph\* 9. sprint 10. variable\* 11. investigation\* 12. table 13. reflect\*   **\*words with Spanish cognates** |
| **Higher Order Questions:**   * What does the body do during a particular sport? * What characteristics may help an athlete be successful? * If a variable is changed, what will happen? | | | | |
| **Social and Cultural Processes:**   * Make connections to home culture. * Make home/school connections. | | | | |
| **Building Background Activities**   * Athlete picture cards * Athlete T-Chart * Vocabulary Activities | | | | |
| **Comprehensible Input and Output**  (See reds text throughout unit.) | | **Learning Strategies**   * Science Notebooks * T-Chart for Social Skills * Numbered Heads Together * Home School Connection * Vocabulary activities | | **Practice and Application:**   * Investigation |
| **Student Interaction**  Whole class, small group and paired discussions take place throughout the lesson. | | | | |
| **Student Reflection**   * Student reflection is done throughout the investigation and is found in the rubric. * Revisit focus question throughout the unit (group or pair discussion, written in science notebooks…). | | | | |
| **Review and Assessment**   * Students self-assess using student rubric * Throughout the investigation, students display, share and get feedback from classmates on each stage of the investigation process | | | | |
| **Parental Support Opportunities**   * Home school connection | | | | |

<http://www.nbclearn.com/portal/site/learn/lesson/b67bdc1505529310VgnVCM10000075c1d240RCRD>

**SCIENCE OF THE SUMMER OLYMPICS**

**The Biomechanics of Usain Bolt: An Engineering Perspective**

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Original lesson plans were produced by the National Science Teachers Association

Video was produced by NBC Learn in collaboration with the National Science Foundation

**Adapted for Middle and High School Migrant Students.**

Washington State Office of the Superintendent of Public Instruction

Migrant Education Program

This adapted module supports the following frameworks and standards:

**Next Generation Science Standards:**

* 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.
* HS-LS1-2 – Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions with multicellular organisms (This unit can be strengthened for high school by connecting to “[Olympic Motion](http://www.nbclearn.com/portal/site/learn/science-of-the-olympic-winter-games).”

***A Framework for K–12 Science Education***

* PS2.A Forces and Motion
* PS2.B: Types of Interactions
* LS1.A: Structure and Function

**Related Science Concepts**

* Force and the resultant pressure on a surface
* Action and reaction forces (running on a track)
* Speed and acceleration of an object (a human body)
* Motion and how human movements result in motion
* Relationship of weight and mass
* Muscular system and how it moves the human body
* Reaction time
* Gene expression due to heredity and environment

**Framework for K–12 Science Education**

* ETS1.A: Deﬁning and Delimiting Engineering Problems
* ETS1.B: Developing Possible Solutions
* ETS1.C: Optimizing the Design Solution

**Common Core State Standards – Math:**

* Math Practice.2 Reason abstractly and quantitatively
* 6. EE.A.2: Write, read, and evaluate expressions in which letters stand for numbers.
* 7.EE.B.3: Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form, using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies
* 7.EE.B.4: Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities.

**Common Core State Standards – English language Arts:**

* **RST.6-8.1** Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions (MS-PS2-1),(MS-PS2-3)
* **RST.6-8.3** Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks. (MS-PS2-1),(MS-PS2-2),(MS-PS2-5)
* **WHST.6-8.1** Write arguments focused on discipline-specific content. (MS-PS2-4)
* **WHST.6-8.7** Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. (MS-PS2-1),(MS-PS2-2),(MS-PS2-5)
* **SL.11-12.5** Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-LS1-2),(HS-LS1-4),(HS-LS1-5),(HS-LS1-7) ion

**Common Core Speaking and Listening Anchor Standards**

* **SL.6:** Adapt speech to a variety of contexts and communicative tasks, demonstrating command of formal English when indicated or appropriate.)

**Engineering in Action**

Mechanical engineers create and build mechanical devices, while biomechanical engineers blend traditional engineering techniques with biological science and medicine. Today, many mechanical engineers are lending their expertise to the analysis of living systems. The development of a prosthetic tail for winter, a dolphin at the Clearwater (Florida) Marine Aquarium, is just one example. Biomimicry – such as modeling the nosecone of a Japanese bullet train after a kingﬁsher’s beak, so the train is quieter as it emerges from tunnels – is a growing ﬁeld as well.

Given a problem, engineers begin the search for a solution by analyzing what they have to work with. In the case of Usain Bolt, Samuel Hamner analyzes the physical attributes of Usain’s body as well as how various parts of his body work together to accomplish his goals. Without being able to observe Usain’s motion—how his bones and muscles move—it would be impossible to improve his motion through an engineering process. Unlike physical mechanical engineering solutions, which can be arrived at through manipulating physical factors, biological engineering problems begin with the genetics of the individual (human or other organism) that is the focus of the problem. While other constraints can inﬂuence the solution, ﬁrst and foremost the engineering solution has to work within the genetic constraints.

Help students explore solutions to a problem related to stride length and speed. (Adapted handouts provided. The lesson on Usain Bolt focuses on the analysis of an action and how adjusting one component of the action inﬂuences the result.

**General Background and Lesson Planning Information**

This unit was taken from NBCLearn and has been adapted for migrant middle and high school students using (among other things) the Sheltered Instruction Observation Protocol (SIOP) components as a guide. The unit integrates specific strategies to support migrant students both culturally and linguistically, while maintaining rigorous Science and Engineering content standards. Although the lesson was specifically adapted for migrant students, teachers will find the adaptations applicable to a variety of students in his/her classroom.

The lesson uses an inquiry-based science approach with strategies and adaptations that support migrant student comprehension of and access to the content curriculum. Specific focus was given to the following components—having clear targets and assessments, using supplemental materials that support learning, adapting the content when necessary, building background by connecting the content to prior learning and the migrant student’s life and experiences, emphasizing key vocabulary, making the information and academic tasks comprehensible through the use of visuals, gestures, examples, modeling, and use of primary language when needed, using strategies that support effective teaching and learning, providing multiple opportunities for student interaction, and practicing and applying what is learned.

Teachers should encourage inquiry using a strategy modeled on the research-based science writing heuristic. Student work will vary in complexity and depth depending on grade level, prior knowledge, and creativity. Use the prompts liberally to encourage thought and discussion.

**Key Vocabulary**

Prediction, evidence, mechanics, stride, calculate, trial, analyze, claim, observation, control

**Other Vocabulary**

Characteristics, advantage, data, length, speed, compare, related, graph, sprint, variable, investigation, table, reflect, stance phase, flight phase

**About the** [**Video**](http://www.nbclearn.com/portal/site/learn/lesson/b67bdc1505529310VgnVCM10000075c1d240RCRD)

Mechanical engineers Dr. Anette Hosoi (Massachusetts Institute of Technology) and Samuel Hamner (Stanford University) study Usain Bolt’s physical structure to help determine how he is able to run so fast. Their ﬁndings might enable them to develop solutions for people with movement disorders or to optimize the performance of athletes.

0:00 0:12 Series opening

0:13 0:59 Introducing Usain Bolt

1:00 1:23 Annette Hosoi describing the uniqueness of Usain’s abilities

1:24 1:58 Usain’s physical characteristics and stride length

1:59 2:17 Usain’s physical characteristics and mass

2:18 2:41 Inﬂuence of muscle strength on force

2:42 3:23 Samuel Hamner’s reasons for studying Usain

3:24 4:09 Running stance phase

4:10 4:27 Running ﬂight phase

4:28 4:48 Electrical signals and coordination

4:49 5:14 Everything coming together for Usain

5:15 5:24 Closing credits

|  |
| --- |
| **Lesson Sequence**  **Time**  The length of time it will take to complete this module will vary greatly depending on the group of students, how much scaffolding is needed, and how the teacher may choose to extend the module. If this is the first time students have engaged in an investigation of this type, it may require more demonstration and modeling and will take longer than if students are experienced in the inquiry model. Experienced students may move more quickly and successfully into a self-directed inquiry.  **Materials**  Black line masters (found in the Appendices at the end of the Lesson Sequence)  Science notebooks  Chart paper  Markers  Measuring tapes  Timers  Athlete Picture Cards (examples in Appendix B)  Access to internet, projector and speakers to show the video at NBC LEARN  **Scaffolding and Differentiation**  Specific scaffolded supports for migrant students are shown in red throughout, but may be useful strategies for other students as well. |
| **Establish Class Expectations For Working Together**  Set up classroom in table teams of 4 heterogeneous students per team. Give teams 1 minute to come up with a team name they all agree on. Have table teams select a team name. Utilizing the GLAD strategy **“T-Chart for Social Skills”** **(Appendix A)**, have class develop the definition for “COOPERATION” and create a T-Chart description of specific cooperative behaviors—(left column, what one would hear, and right column, what one would see)—if students were cooperating. Be sure each team has a team name in order to give team points for evidence of the cooperative behaviors during small group activities in this lesson. |
| **Explore Understanding (Build Background and Context)**  Create famous athlete picture cards prior to lesson by putting a picture of a famous athlete on one side and the athletes profile, statistics or facts on the reverse side of an 8.5x11 card. Try to find athletes that will generate student interest and motivation and with whom a migrant student may identify. **(Sample athlete picture cards are found in Appendix B.)** One at a time, show the class each athlete’s picture and read their profile the back. Then let each table team choose one athlete picture card for the following activity.  Display on the board and orally demonstrate the following prompt: “During \_\_\_\_(insert physical sport activity)\_\_\_\_\_\_\_\_\_, the body \_\_\_\_(insert a description of what the body does during this sport)\_\_\_.” **(Appendix C)** Example: “What does the body do during swimming the backstroke?” “During swimming the backstroke, the swimmer stretches their arms overhead and pulls them down through the water in a circular motion. The body must also flutter kick the feet, stay afloat face up, and breathe.” Use gestures while describing with words what the body do while swimming the backstroke. Point to the written prompt on on the wall. (Appendix C)  Pass out one “Athlete T-Chart” **(Appendix D)** to each table team. Go through the oral prompt again, but this time show students (on document camera or chart paper) how to fill in the left column on their athlete t-chart with the body’s responsibilities during the particular sport being demonstrated. Use bullets and phrases on the t-chart rather than full sentences. (See **Appendix E** for a sample of filled in athlete t-chart.) Do not have them write on their t-chart until next step.  Prompt the students to think (in their heads) about the athlete on their card. Ask them to think about what the body does during that sport. After the think time, each student in the team takes a turn to share out to the team one thing that the body does while doing that particular sport. Permit students to use a gesture, their primary language, or a sketch to express their thinking. Sometimes a sport may be done differently in a different country, so allow for this possibility. Answers are recorded in the left column of the team’s athlete t-chart by a team recorder.  Go back to whole class demonstration (document camera or chart paper) and do a think aloud about what characteristics to you think an athlete needs to do that sport. Use the prompt: “Characteristics that (I think) may help a \_\_\_(swimmer)\_\_\_ be successful are…” **(Appendix F)** As you think aloud, write your answers in bulleted form in the right hand column of the t-chart on the wall. You might need to supplement the discussion with additional images or demonstrations of actions involved in some sports, such as golf or discus. NBCLearn is a good source for video clips of other sports in their “The Science of the Summer Olympics” series and their “The Science and Engineering of the 2014 Winter Olympics” series.  Now ask students to first think, then share out one at a time in their table teams. They will each share one characteristics (physical or other) that might inﬂuence how their team’s athlete excels at his or her sport. Permit students to use a gesture, their primary language, or a sketch to express their thinking. Sometimes a sport may be done differently in a different country, so allow for this possibility. A team recorder will write the answers in the right column of the team’s athlete t-chart. Use Spencer Kagan’s cooperative strategy called Numbered Heads Together **(Appendix G)** to have the teams share out one characteristic from their t-chart that they think contributes to their athlete’s success. This strategy helps hold every member of the team accountable for the learning. Teams display their athlete’s picture and t-chart on the wall for future reference.  Teacher revisits the T-Chart for Social Skills and asks teams one by one (using numbered heads together strategy) if their team has “earned” points for ‘cooperating’ on the previous activity. Team points are recorded on the team points chart that is next to the T-Chart for Social Skills. |
| **Introduce and Assign the Home School Connection**  Pass out the Home-School Connection **(Appendix H)** to every student. Tell students that they need to go home tonight and talk to their parents (or other adult living at home) about their parent’s favorite athlete or any athlete they may know of. Have students ask the parent to tell them what body mechanics they think are involved in that sport, as well as what physical characteristics the parent thinks are needed to excel in that sport. Students will record the parent’s responses on the Home-School Connection and bring it back to school to share with the class. The next morning, use numbered heads together and have someone from each team share out what their family member said. The home-school connections are turned in and team (bonus) points are given when all members of the team have turned in their assignment (cooperation). If someone is missing an assignment, they can bring it in tomorrow and the bonus points will be given at that time. |
| **Direct Vocabulary Instruction—Introduce Key Vocabulary**  Provide students with a student friendly definition for the key vocabulary words of the module and a sentence that describes how each word is used (the context in this particular Science/Engineering module). **Appendix I** #1 and #2 describes the process for introducing contextualized key words and providing a student friendly definition.  Have students enter vocabulary into their science notebooks. **(Appendix O)** |
| **Continue to Explore Understanding**  Show the video SOTSO: The Biomechanics of Usain Bolt at <http://www.nbclearn.com/portal/site/learn/science-of-the-summer-olympics>  To support non-English proficient migrant students, make available a printed transcript of the video which is available at the NBCLearn website above. Click the “Transcript” tab on the side of the video window, then copy and paste into a document for printing/student reference. If needed, translate the video transcript document into the students’ primary language. If student is not literate in his/her primary language, have someone read the translated transcript to the student in their primary language. Create a VOD cast of the transcript for students to click on and listen to.  Ask the students to focus on Usain’s physical characteristics while watching the video. Stop the video at 1:37 and ask students to turn to their table partners and make predictions about how Usain’s height gives him an advantage. Provide the oral frame that you want students to use while they orally share. Example: “In my opinion, Usain’s height gives him an advantage because…” **(Appendix J)** Give students 1 minute to think of their prediction and 2 minutes to share their predictions orally in their table teams. Permit students to use a gesture, their primary language, a word or phrase instead of a complete sentence, or a sketch to express their thinking.  As the video is resumed, encourage students to jot down notes about Usain’s physical structure. After the video concludes, show the following question prompts on screen. **(Appendix K)** Go through each of the prompts verbally first, gesturing when possible for comprehension. Each of the prompts is written in the form of an oral frame to support student discourse. After modeling each of the prompts, give students one minute to choose one and think (silently) about their answer. Then give students 3 minutes to share their answers in their table teams, using the oral frame provided for the prompt they choose. Teams may share out to whole group using Numbered Heads Together if time is available.   * When I watched the video I thought about \_\_\_\_\_. * The expert in the video claimed that \_\_\_\_\_ because \_\_\_\_\_. * Usain is not expected to run so fast because \_\_\_\_\_. * If “mechanics” is about how something works, then “biomechanics” is about \_\_\_\_\_. * Because Usain is bigger, he has to compensate by \_\_\_\_\_. * The stance phase in running diﬀers from the ﬂight phase by \_\_\_\_\_. * I would like to know more about \_\_\_\_\_. * I would do research to ﬁnd out more about \_\_\_\_\_.   Teacher may request students to write responses to their prompts in their science notebooks.  Teacher revisits the T-Chart for Social Skills and asks teams one by one (using numbered heads together strategy) if their team has “earned” points for ‘cooperating’ on the previous activity. Solicit which specific behaviors from the chart provided evidence of the team’s cooperation. Team points are recorded on the team points chart that is next to the T-Chart for Social Skills. |
| **More Direct Vocabulary Instruction—Practice and Reinforce**  Have students work in pairs or small groups and complete Activity 1 and 2 found in **Appendix I**, page 4. |
| **Introduction to the Investigation**  The original NBCLearns module provides the teacher a choice of two different approaches for the investigation process—an open choice approach or a focused approach. The original module has been adapted to provide teachers a scaffolded inquiry process continuum for the investigation. The continuum incorporates a highly scaffolded (teacher guided) process, which then moves through a collaborative small group approach to the ultimate semi-independently directed student approach. It is the “I DO, WE DO, YOU DO” scaffold that provides situational support for all levels of students. Use the document “Scaffolding the Inquiry Process” **(Appendix L)** to carry out the following investigation. |
| **Develop a Testable Question**  Use the “Scaffolding the Inquiry Process” document to support students in writing a testable question for their investigation. Have them use their Science notebooks to record their work for this step of the investigation. |
| **Make Predictions**  Use the “Scaffolding the Inquiry Process” document to support students in making a prediction that will describe what will happen as a result of their investigation. Have them use their Science notebooks to record their work for this step of the investigation. |
| **Identify and Define the Variables**  Use the “Scaffolding the Inquiry Process” document to support students in identifying and defining the manipulated, controlled and responding variables for their investigation. Have them use their Science notebooks to record their work for this step of the investigation. |
| **Write the Procedure**  Use the “Scaffolding the Inquiry Process” document to support students in writing a the procedure for their investigation. Have them use their Science notebooks to record their work for this step of the investigation. |
| **Collect the Data**  Use the “Scaffolding the Inquiry Process” document to guide students in the data collection for their investigation. Have them use their Science notebooks to record their work for this step of the investigation. |
| **Make a Claim Backed by Evidence**  Use the Scaffolding the Inquiry Process document to support students in making a claim that is supported by measurements, observations, and patterns from their investigation data. Have them use their Science notebooks to record their work for this step of the investigation. |
| **Communicate Explanation and Reasoning**  Use the Scaffolding the Inquiry Process document to support students in communicating their explanation and reasoning. Have them use their Science notebooks to record their work for each step of the investigation. |
| **Assessment**  Table teams will use the student investigation rubric **(Appendix M)** to team-assess each piece/step of their investigation. They will display their question, the design of their investigation of the question, and their findings, including their claims, evidence and reasoning, and will orally defend their assessment rating. The teacher version of the rubric is found in **Appendix N**.  Rather than a team self-assessment, you may choose to have teams assess each other using the assessment rubric and learn to look for evidence of their assessment rating and communicate their evaluation orally or in writing.  If time and equipment/materials permit, students could be encouraged to develop a 5 minute video of their investigation and claims similar to the Usain Bolt video as an example.  Another authentic assessment, time permitting, is to have students conduct another similar biomechanics investigation (less guided/more independently driven) on another athlete or sport. This could be an end-of-course project that is written up, displayed and the findings communicated in many different ways. The student can self-assess and orally defend the assessment with evidence. |
| **Reflection**  Revisit the focus question…students may create an individual written response in their science notebooks and then share out with a partner or team. Students may want to edit or add to their response after discussing it. |

**More Ways to Incorporate the Usain Video into Your Lesson Plan**

**Integrate Video in Instruction**

**Bellringer**

Play the video as students gather for class, repeating at least once. Instruct students to listen and watch for Usain’s personal reactions to his running prowess and training regime.

Then have the students brieﬂy discuss how Usain’s attitude might have both positive and negative impact on his success.

**Visualize a Concept**

A 25-second segment beginning at approximately 1:59 relates the components of an action-reaction force between Usain and the track.

Use this as a practical application of the concept during a discussion of Newton’s three laws of motion.

**Using the 5E Approach?**

If you use a 5E approach to lesson plans, consider incorporating video in these E’s:

**Engage**

Use the video to prompt students’ thinking about how the intensity of action-reaction forces between a runner and the ground are dependent on factors such as mass and speed. Students might begin to generate questions that can become the focus of supporting inquiry activities.

**Elaborate**

Use the video to extend understanding of the interaction of heredity and environment in humans. Students can hypothesize how Usain and other athletes or celebrities with speciﬁc physical attributes – such as large muscles or ﬂexible limbs – are impacted by training regimes and nutrition.

**Connect to STEM**

**Math**

Students might research distances for various races, and determine how quickly Usain could complete each race if he were able to maintain his sprinting speed and stride length over longer distances. Students might make comparisons with winning times in famous marathons, such as those held in Boston or New York, or other Olympic events. Students also might calculate their own top speed and stride length and compare those with their calculations for Usain.

**Use the Video in Assessment**

To assess student understanding of the interaction of body systems – or speciﬁcally, just the muscular and skeletal systems – play any one of the segments showing Usain running, with the sound muted.

Then give the following instructions:

*Describe what is occurring among body systems (or between muscles and bones) to enable Usain to move so quickly.*

APPENDICES

(SUPPORTING DOCUMENTS)

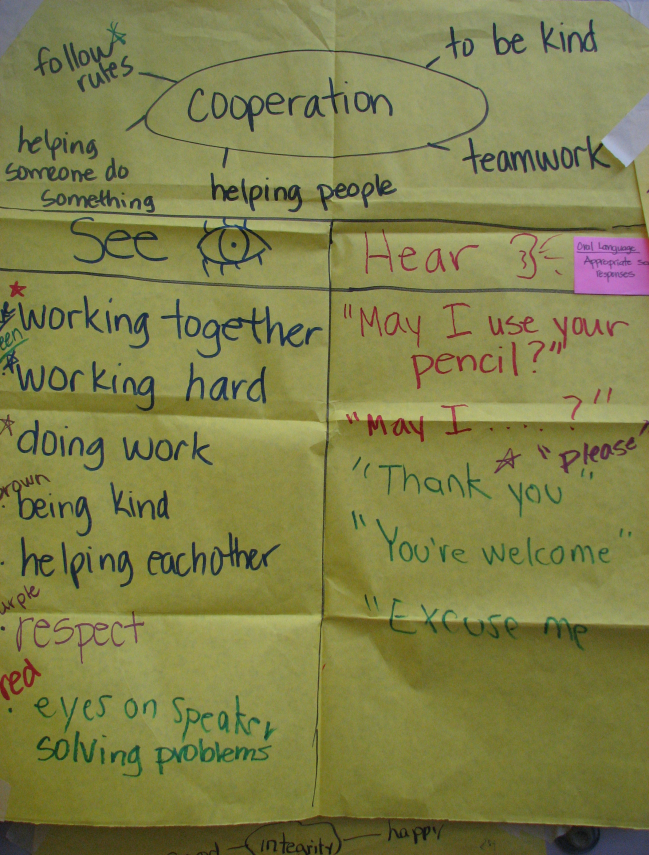
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T-Chart for Social Skills Appendix A

**T-Chart for Social Skills**

WHAT IT LOOKS LIKE



RESEARCH BASE / SOURCE

* Based on the Dee Dishon Model of Cooperative Learning (positive interdependence)

WHY DO IT? This strategy:

* Emphasizes the importance of social skills
* Sets clear expectations for behavior in teamwork
* Helps students personally and actively practice the social skill
* Helps students practice identifying the skill appreciating it in others
* Helps students identify and articulate the value of social skills in teamwork
* Motivates students to practice the skills in their teams to earn points
* Is a visual recognition of students practicing positive social skills
* Promotes and builds positive interdependence
* Demonstrates the tremendous strength of students working together
* Encourages positive behavior when working in teams

STEP-BY-STEP PROCESS

1. Create a T-Graph on yellow butcher paper (stands apart from the white charts) and post for the class to see.
2. At the top of the T-Graph, write the name of the skill to be practiced.
3. Create a “mind map” around the word by having teams answer the prompt: “Tell me what your team understands by *cooperation?”* Its purpose is as a diagnosis to see how well the students articulate the skill. It’s an assessment of their background knowledge around the skill of cooperation.
4. In one column write "See": “What would I see if you were cooperating?” In the second column write "Hear": “What would I hear if you were cooperating?”
5. Entries on the chart are solicited one team at a time, using numbered sticks. Each student in the table team is given a number (i.e., 1-4.) When it’s time for their team to answer, a numbered stick is drawn and that team member is the one who will share out the teams answer. This is important for support and accountability. Response examples are tone of voice, smiling, eyes on speaker, sharing, etc.
6. Honor student responses but nudge them forward to more concrete examples. It’s OK to change what they say with their permission. If they offer an example stated in the negative (eg., “Students would not be fighting”), ask them to turn it around to a positive by saying “So, if students were not fighting, what would they be doing? What would I see? What would I hear?”
7. Get a response from each team. This is not a time for choral call or individual shout outs.
8. During the week, add additional comments or ideas to the chart, using a different colored marker each day. The colors will show growth and learning.

**NOTES**

* Different social skills practiced through the year by using a new skill for each unit (i.e., perseverance, cooperation)
* What is heard or seen is stated in the positive.
* “No Cheating” - “What are you doing if you are not cheating?”
* It is an assessment of what the class knows about ”cooperation”
* Revisit the T-Graph frequently to note growth and learning.
* Do not write individual student names on this chart. It is all team-based.
* Teacher does not ‘give’ team points. Teams "EARN" team points.
* The Washington State Communication EALRs provide suggestions for behaviors and vocabulary that may be used to develop the TChart of Social Skills.

**COMMUNICATION EALR 2:**

* The student uses communication skills and strategies to interact/work effectively with others.
* Uses language and communication strategies to interact effectively and responsibly in a multicultural context; to work collaboratively, solve problems, and perform tasks. Understands how to show respect for others’ input. Applies skills to contribute responsibly in a one-to-one conversation or group setting. Uses skills and strategies to communicate interculturally. Understands that individuals may have differing opinions, perspectives, and meanings for communication.
* Selects language that is respectful of others’ feelings and rights (e.g., no threats, bullying, or derogatory or discriminatory language).
* Chooses language that builds relationships in classroom activities or role-playing situation (e.g., supportive, encouraging, constructive).
* Expresses one’s self and uses turn taking cues so that everyone has a chance to speak (e.g., a pause may be a cue for taking turns; the length of the pause may vary between children).
* Expresses support and acceptance by showing interest and seeking ideas and conclusions (e.g., “I like what you shared about your snake, Collin. Do all snakes lay eggs?”).
* Demonstrates respectful disagreement (e.g., “I think you have a good idea, Keisha, but did you think about …?”).
* As a listener, responds to the speaker with encouraging nonverbal communication (e.g., smiling, clapping, and nodding at appropriate times).
* Sustains conversation by expressing and soliciting comments or opinions (e.g., What do you think? How would you do it? Do you agree with that?).
* Reaches a group decision through compromise, (e.g., blending differing points of view to reach a compromise or choosing the quickest or best solution).
* Identifies and demonstrates rules that guide small group work (e.g., takes turns, stays on topic, contributes equally, and encourages contributions of others).
* Assumes assigned role in group for completion of a task (e.g., leader, reporter).
* Shares one’s own opinion and compares it to others’ (e.g., “Jason likes to swim, but I’m afraid of the water.”).

**VARIATIONS**

* For elementary, be sure to role play the word and add a sketch or icon that depicts cooperation.

**Athlete Picture Cards Appendix B**

**Javier “chicharito” Hernandez Balcazar**

(2014). Javier “chicharito” Hernandez Balcazar. Retrieved January 22, 2014, from http://javier-hernandez.net/about.php

**JAVIER “CHICHARITO” HERNANDEZ BALCAZAR**

Javier Hernández Balcázar, commonly known as "Chicharito", is a Mexican footballer who plays as a forward for Manchester United, being the first Mexican to do so.   
He previously played for Mexican club Guadalajara. He made his début for the Mexico national football team in September 2009 in a match against Colombia and represented them at the 2010 FIFA World Cup scoring two goals.



**LeBron James**

**aka “King James”**

(1996-2013). A+E Television Networks. LLC.

Retrieved January 22, 2014, from http://www.lebronjames.com.

**LeBRON JAMES**

**aka “King James**

Standing at six feet, eight inches tall and weighing in at 250 pounds, James has been called the best physical specimen in sports by some sports analysts. He has started at [small forward](http://en.wikipedia.org/wiki/Small_forward) and [power forward](http://en.wikipedia.org/wiki/Power_forward_(basketball)), but can also play the other three positions. With career averages of 27.6 points, 7.3 rebounds, 6.9 assists, and 1.7 steals per game he is considered one of the most versatile players in the NBA, and has been compared to Hall of Famers Oscar Robertson, Magic Johnson, and Michael Jordan. James has earned All-NBA honors every season since his sophomore year, All-Defensive honors every season since 2009, and was named Rookie of the Year in his debut season. With four MVP awards, he is part of a select group of players who have won the award four times, including Kareem Abdul-Jabbar, Jordan, Wilt Chamberlain, and [Bill Russell](http://en.wikipedia.org/wiki/Bill_Russell).

[](http://www.bing.com/images/search?q=liliana+ibanez&qpvt=liliana+ibanez&FORM=IGRE#view=detail&id=508070860F623C20654639CF2F0C4C1AB8EC7A12&selectedIndex=78)[](http://www.bing.com/images/search?q=liliana+ibaniez&qpvt=liliana+ibaniez&FORM=IGRE#view=detail&id=DF71159FEAC3C9E13864658736A666014D2D2A20&selectedIndex=17)

**Liliana Ibañez**

(2014). Texas A&M University. http://www.aggieathletics.com/ViewArticle.

**LILIANA IBAÑEZ**

**Liliana Ibáñez** ([Celaya](http://en.wikipedia.org/wiki/Celaya), Guanajuato, 30 January 1991) is a Mexican swimmer.Liliana Ibáñez is the daughter of Bernardo Ibáñez and Soccoro Lopez born Jan. 30, 1991 in Celaya, Guanajuato, Mexico. She is an architecture major at Texas A&M University. At the [2012 Summer Olympics](http://en.wikipedia.org/wiki/2012_Summer_Olympics) she finished 26th overall in the heats in the [Women's 200 meter freestyle](http://en.wikipedia.org/wiki/Swimming_at_the_2012_Summer_Olympics_%E2%80%93_Women%27s_200_metre_freestyle) and failed to reach the semifinals, but has posted the third fastest times in school history in three events; the 50 free in 22.21, the 100 free in 48.38, and the 200 free in 1:44.44.





**Lorena Ochoa**

(2014). Kelley Brent. About.com; Retrieved on January 22, 2014 from http://websearch.about.com

**LORENA OCHOA**

Lorena Ochoa Reyes is the best Mexican athlete of all time and was the number one female golfer in the world for 157 weeks in a row. She was born in Guadalajara, Jalisco on November 15, 1981. Lorena started playing when she was five years old and her career advanced very fast. At six, she won her first state championship; at seven, a national one; at eight, she ranked number one in the World Junior Golf Championship and at thirteen, she was the only player in the world to win for five consecutive years the Junior World International Championship and the World Junior Golf Championship; a record that Lorena still holds. Lorena started her professional career in 2002 on the Futures Tour, where she won three tournaments and ranked first place on the money list; this granted her a place on the LPGA. Five years later, in 2007, Lorena Ochoa, at only 25 years of age, ranked number one of the world.



**Hugo Sanchez Marquez**

(2008-2009). Sports-Wiki. Retrieved January 22, 2014, from http://www.soccer-fans-info.com/hugo-sanchez.html.

**Hugo Sanchez Marquez**

Hugo Sánchez Márquez is a Mexican football coach and former striker. He played for four European clubs, including Real Madrid. He was also a member of the Mexico national team, and participated in three World Cups. Born in Mexico City, Hugo Sanchez Marquez was fast to make a name for himself. As a young footballer, Hugo Sanchez managed to get into the ranks of the youth squads of the [Mexican national soccer team](http://www.soccer-fans-info.com/mexico-soccer-team.html), playing in over 80 international games before he reached the age of 18 and was eligible for a professional contract





**Hope Solo**

(1996–2013). A+E Television Networks, LLC. Retrieved January 22, 2014 from http://www.biography.com/people/hope-solo.

**HOPE SOLO**

Solo was born in [Richland](http://en.wikipedia.org/wiki/Richland,_Washington), [Washington](http://en.wikipedia.org/wiki/Washington_(state)) on July 30, 1981 to Judy and Jeffrey Solo. Her father, an Italian-American [Vietnam War veteran](http://en.wikipedia.org/wiki/Vietnam_veteran), who was in and out of her life as a child and teenager, taught her how to play soccer at a young age. Solo is regarded as one of the top goalkeepers in the world. She was the starting goalkeeper for the majority of the [2007 FIFA Women's World Cup](http://en.wikipedia.org/wiki/2007_FIFA_Women%27s_World_Cup) and helped lead the U.S. national team to the semifinals having given up only two [goals](http://en.wikipedia.org/wiki/Association_football_pitch#goals) in four games, including three consecutive [shutouts](http://en.wikipedia.org/wiki/Shutouts).

Prompt and FrameAppendix C

What does the athlete’s body do during a particular sport?

During \_\_\_\_\_\_\_\_\_\_,

the athlete \_\_\_\_\_\_\_\_\_\_\_\_\_\_.

Athlete T-Chart Blank APPENDIX D

|  |  |
| --- | --- |
| Athlete: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  Sport: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | |
| Describe what the body does during this sport. | List characteristics that may help this athlete excel. |
|  |  |

Athlete T-Chart Example APPENDIX E

|  |  |
| --- | --- |
| LILIANA IBAÑEZ  Swimming (Freestyle) | |
| During the sport of freestyle swimming, the body… | Characteristics that might help a freestyle swimmer are… |
| * …uses outstretched arms to pull through water * …uses legs and feet to flutter kick * …bends and twists to make turns * …holds its breath during several strokes with face in water * …turns face up out of the water to breathe every few strokes | * Long, strong arms * Long, strong legs and feet * Flexible trunk (waist and torso) * Ability to hold breath for a longer time while under exertion * Strong flexible neck muscles |

Prompt and Frame APPENDIX F

What characteristics might help a freestyle swimmer to be successful?

Prompt and Frame (continued) APPENDIX F (Continued)

A freestyle swimmer needs long

arms, strong legs, a thin body,

and short hair to be successful.

Prompt and Frame (continued) APPENDIX F (Continued)

A \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ needs \_\_\_\_\_\_\_\_\_\_\_, \_\_\_\_\_\_\_\_\_\_, and \_\_\_\_\_\_\_\_\_\_\_\_\_ to be successful.

Numbered Heads Together APPENDIX G

**NUMBERED HEADS TOGETHER**

**RESEARCH BASE**

The basic structure of Numbered Heads Together comes from Spencer Kagan;, however, a number of variations exist.

**WHY DO IT?**

**Create Positive Interdependence:** The students are able to learn from each other. They must also work together to ensure there is one product to their learning. They must check that everyone can understand and answer the question.

**Individual Accountability:** Students are accountable to each other for sharing and developing ideas. Every student must be able to give the team response to the question.

**Equal Participation:** Each student within the group has an equal opportunity and expectation to share.

**Simultaneous Interaction:** High degree of interaction. At any one moment all of the students will be actively engaged in purposeful speaking and listening.

**STEP-BY-STEP PROCESS**

* 1. Ideally form teams of four students. Each team is assigned a team color. Each student takes a number up to four. There may be one or two teams of three but no teams larger than four.
  2. Teacher poses questions or problems to the whole class.
  3. Teacher asks teams to “put your heads together”. “Everyone must be able to articulate the thoughts or answers your team discusses”. It must be stressed that it is the expectation that everyone in the team must participate in resolving the question or problem.
  4. Teacher gives adequate ‘wait time” for the team to complete the task.
  5. Teacher now asks for a response by calling a team color and a number. (Numbered craft sticks in a cup.) The student with the number called answers for the team.
  6. If the student is unsure and needs more time, the teacher will say,”heads back together red team. We’ll come back you” No one gets let off the hook.

**NOTES**

Numbered Heads Together provides higher order thinking and engagement with academic language for all levels. The more confident student has the opportunity to review and cement language and concepts by “teaching” to classmates and the ELL student that is just mastering the basics is not left out. Even the ELL Level 1 student is expected to share the team’s thinking, even if it is being handed to the student word by word. There is accountability for all student

Home-School Connection (English) APPENDIX H

**Usain Bolt Science Module**

**Home/School Connection**

1. Ask your parents to think of an athlete they admire.
2. Ask them to tell you what they think the body does during that particular sport’s physical activity.
3. Ask them to also tell you what physical (or other) characteristics that athlete needs to excel in that sport.
4. Write or sketch their answers in the chart below.

|  |  |
| --- | --- |
| The person you spoke to: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  Their athlete’s name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Their athlete’s sport: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | |
| Describe what they said the athlete’s body does during this sport. | List the characteristics that they think will help this athlete excel. |
|  |  |

Think about a sport in which you, or someone you know excels. What characteristics makes you (or your friend) good in that sport? Share your thoughts with your parents or family member.

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

Your Parent’s Signature: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Home-School Connection (Spanish) APPENDIX H (continued)

**Lección de Ciencias: Usain Bolt**

**Conexiones al Hogar**

1. Pide a tus padres que piensan en un atleta que admiran.   
2. Pídales que te digan lo que piensan de que el cuerpo hace durante la actividad física de ese deporte en particular.   
3. Pídales también que te digan qué características físicas (u otras características) necesita el atleta para sobresalir en ese deporte.   
4. Escriba o dibuje sus respuestas en la tabla abajo.

|  |  |
| --- | --- |
| La persona con quien hablaste: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  El nombre del atleta: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ El deporte del atleta: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | |
| Describe lo que dijeron acerca de lo que hace el cuerpo durante este deporte. | Escriba las características que ellos piensan ayudaran a sobresalir este atleta. |
|  |  |

Piensa en un deporte en el que tú, o alguien que conoces, se destaca. ¿Qué características tienes (o tu amigo tiene) que te hace sobresalir en ese deporte? Comparte tus pensamientos con tus padres o un familiar.

Tu nombre: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Firma de tu padre o madre: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Supplemental Vocabulary Support Documents APPENDIX I

**Supplemental Vocabulary Support**

To Accompany the Usain Bolt Science Module

# Introduction to the Identification of Key Vocabulary

# Most educators agree that many (not all) vocabulary words in a lesson require some direct instructional support in order for students to learn their meanings, context as well as the content of the lesson being taught. However, determining which words to target for direct instruction is not an easy task for teachers. Beck, MeKeown and Kukan (2013) suggest that since there is not enough time to dedicate equally to all vocabulary, the most effective way to prioritize vocabulary is to identify (Tier Two) words that are “of high utility…and are found across a variety of domains.” High oral frequency words (Tier One) are generally already known or learned independently because they are highly contextualized and frequently used in conversation. Beck et.al. also suggest that (Tier Three) words which are very specific to a particular topic or domain (like filibuster, pantheon, epidermis, photosynthesis) also do not necessarily require direct vocabulary teaching because these words are generally understood through context and example. Identifying the Tier Two words is most critical because they are often used in multiple contexts, are characteristic of written texts, and are found infrequently in conversation which makes them more difficult for the student to learn independently. Some examples of Tier Two words are contradict, precede, retrospect, fervent, circumstance, and analyze. Finally, if any of the targeted vocabulary words happen to be English cognates (words that come from the same root or origin, are spelled similarly and sound enough alike) students may be able to guess their meaning. However, beware of false cognates (words that may sound and look similarly but have a very different meaning), and think about whether or not the student would have already been exposed to the cognate word in their primary language.

# Key Vocabulary

Although your identification of key vocabulary words for this lesson may be different, the Tier Two words we have identified as needing some direct instructional support are listed below.

|  |  |  |
| --- | --- | --- |
| Suggested Vocabulary List | Additional Vocabulary Words if Desired | |
| 1. prediction\* 2. evidence\* 3. mechanics 4. stride 5. calculate 6. trial 7. analyze 8. claim 9. observation\* 10. control\* | 1. characteristics\* 2. advantage 3. data\* 4. length 5. speed 6. compare 7. related 8. graph\* 9. sprint 10. variable\* 11. investigation\* 12. table 13. reflect\* 14. stance phase 15. flight phase |

\*Words with Spanish Cognates

Supplemental Vocabulary Support Documents APPENDIX I (continued)

# Direct Instruction of Vocabulary—Five (5) Tips

# Research has shown that simply providing a word list and definitions is an ineffective way to teach vocabulary. Beck, McKeown and Kucan (2013) stress that in order to really own new words, students must have multiple opportunities in which to interact with them. The 5 tips listed below are suggested general ways to introduce words and have students apply and actively process meaning with words in any content at any grade level. Following the 5 tips are specific vocabulary activities tied to the vocabulary in this Usain Bolt Science Module.

1. **Provide Context**

Initially, students need to hear the words in an authentic context. Provide your students with a sentence that describes how each word or concept is used (context) within this particular unit. Example: In the video, the narrator says Usain Bolt’s race is still one which people *analyze.*

1. **Provide Student Friendly Explanations**

Two basic principles should be followed to create student friendly explanations.

1) Characterize the word and how it is typically used. We did this above under Provide Context.

2) Explain the meaning in everyday language. Our list of suggested key vocabulary may differ from yours, but here is a list of sample student friendly explanations for the suggested list.

1. Prediction – a statement about what you think is going to happen
2. Evidence – facts or signs that clearly show that something is true
3. Mechanics – the details of the way something works or is done
4. Stride – a long step you make while you are walking or running
5. Calculate – to find out how much something will cost, how long something will take etc. by using numbers
6. Trial – a process of testing to find out whether something works
7. Analyze – to examine or think about something carefully, in order to understand it
8. Claim – to say that something is true, even though it has not been proved
9. Observation – something that you notice when watching something or someone
10. Control – The group or factors in which nothing changes at all throughout the experiment
11. **Provide an Additional Context for the Word**

We don’t want our students to limit their use of the new words to the context in which they were introduced. So after the contextual introduction and word-meaning explanation, students should be presented with other contexts of the word – that is, provide a sentence that shows how each word can be used in a context or situation that is not the same as in the unit.

1. **Provide opportunities for students to actively process word meanings**

It is essential to have students use the new words themselves while actively processing the new word. A major goal of deep processing is prompting students to make connections between new words and words already known and situations that may apply to the word.

1. **Provide for a high frequency of encounters over time**

Continue to use the words and engage the students with the words. Students should be expected to use the new words often.

Below are examples of simple activities to help your students engage with the vocabulary in this module. The activities should not be done all on the same day, but sprinkled throughout the entire lesson, providing multiple opportunities for students to engage with (and learn) the new vocabulary.

Supplemental Vocabulary Support Documents APPENDIX I (continued)

# Vocabulary Activities to Supplement Lesson

## Activity 1:

Ask students to respond to the following questions and to **explain** their choices:

1. If someone were to make a *prediction*, would you believe them?
2. Is *evidence* more like a fact or make believe?
3. Is understanding the *mechanics* of something, the same thing as knowing how something works or why something works?
4. If someone is *striding* towards you, are they walking slowly or quickly?
5. Is someone who *calculates* how much time they will need to do something a person who plans or a person who does things at the last minute?
6. If a product has undergone multiple *trials,* would you trust the outcome?
7. If someone *analyzes* their reading homework, are they doing it quickly?
8. Would a company make false *claims* about their products?
9. If a person is a careful *observer,* would they notice small details?
10. Is a *control* more like something that changes or that doesn’t change?

### Activity 2:

Have students form small groups of three or four, and ask each group to create a list based on brainstorming about some of the items below (3-4 at most). Also, make sure that each item is given to at least two groups. Then the groups can compare their responses. When groups finish their brainstorming, lead a discussion in which each group explains their ideas to the rest of the class.

1. Come up with several *predictions* that you have heard or make up your own.
2. Describe situations when having *evidence* would be important.
3. Give examples of things that you would like to know the *mechanics* of?
4. Give examples of times when using a long *stride* might not be appropriate.
5. Imagine some conditions or circumstances that you wish you could *calculate.*
6. Give examples of things that you think might have undergone many *trials.*
7. Come up with situations that you might need to *analyze* something or someone?
8. Find out what types of *claims* people in the group say about education, television, or athletics.
9. Describe professions/jobs that it would be useful to be able to make good *observations.*
10. Describe why it would be important to have a *control* when doing an experiment.

### Activity 3:

Ask students to describe what is alike and/or different for the following pairs of words:

1. *Prediction/claim*
2. *Analyze/observation*
3. *Observation/evidence*
4. *Control/trial*

Supplemental Vocabulary Support Documents APPENDIX I (continued)

### Activity 4:

Ask the students to place word phrases on a word line that represents a continuum, and to explain their placement of the various items. An important point here is that there is no correct ordering of the items. The value of the formal is in eliciting students’ explanations that involve target word meanings.

**How much energy does it take to . . .**

1. *Stride* to class?
2. *Observe* a dog on a walk?
3. *Calculate* the distance from the Earth to the Sun?
4. *Analyze* a poem?
5. Look at the *mechanics* of a watch?

Least energy\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_most energy

**How happy would you be . . .**

1. …if the weather man *predicted* rain on the day of your Birthday party?
2. …if the police had *evidence* that you robbed a bank?
3. …after finishing four *trials* in science class?
4. …your mom *claimed* that you were her favorite child?
5. …you were selected to be in a study to see if kids exposed to a new video game increased their math skills and you were in the *control* group?

Least happy\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_most happy

### Activity 5:

These activities all ask the students to use the vocabulary words in a written task.

1. Think of a time when you might need to observe, predict, or analyze. Write a paragraph to tell about it.

Complete the following sentence stems:

1. The Prince *strides* over to the Princess because…
2. The dog *calculates* how long his owner will be out of the house because…
3. The student wants to know about the *mechanics* of a computer because…
4. The doctor wants to conduct a *trial* for a new cancer drug because…

You can prompt students to use several of their words in a writing assignment by providing an interesting premise and asking them to use a specific number of their words or words of your choice in the story. Try to create a premise that your migrant students could connect to such as the #3 example below.

1. You arrive in a white room with no windows and only one door and people waving their hands in the air
2. You go to the mall and all the lights go out
3. Since your mom went to work early in the morning, she asks you to drop off your baby sister at school. When you arrive, there are no children, only a book entitled “The Legend of the Cucuy.

Prompt and Frame APPENDIX J

How does Usain’s height give him an advantage?

In my opinion, Usain’s height gives him an advantage because \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

Video Question Prompts APPENDIX K

* When I watched the video I thought about \_\_\_\_\_.
* The expert in the video claimed that \_\_\_\_\_ because \_\_\_\_\_.
* Usain is not expected to run so fast because \_\_\_\_\_.
* If “mechanics” is about how something works, then

“biomechanics” is about \_\_\_\_\_.

* Because Usain is bigger, he has to compensate by \_\_\_\_\_.
* The stance phase in running diﬀers from the ﬂight phase by \_\_\_\_\_.
* I would like to know more about \_\_\_\_\_.
* I would do research to ﬁnd out more about \_\_\_\_\_.

|  |  |  |  |
| --- | --- | --- | --- |
| Scaffolding the Inquiry Process: From Guided to Open-Ended Appendix L | | | |
| **Scaffolding the Inquiry Process: From Guided to Open-Ended** | | | |
| **Formulating Investigable Questions and Predictions** | | | |
|  | More Guided  **I DO**  Teacher demonstrates/models (whole class) | **WE DO**  Small groups/Table teams | More Open-Ended  **YOU DO**  Individuals |
| **Developing a Testable Question**  ***CRITERIA:***  *The question requires empirical evidence to answer. (It can be answered through an experiment or investigation.)*  *The question is practical and can be investigated at school, (in the classroom or outside) with existing resources.* | Teacher provides a focus/testable question to investigate and demonstrates why it is an investigable question. An example in this unit could be: “How does changing the stride length impact speed in race walking?” The teacher then critiques the question against the criteria to show the correspondence between the question and the criteria. Teacher describes how the class can conduct an investigation that will answer this question. Teacher describes how the measurements will lead to a claim about the impact of stride length on speed in race walking, and describes how the class can investigate this question here at school with the resources on hand. To further student understanding of what is a testable question, the teacher also demonstrates with a question that does not meet one or more of the criteria.  The teacher then facilitates a class brainstorm where students suggest questions to investigate and select one to vet together as a class. (See sample questions below.) Teacher leads class through a whole class critique of the question against the provided criteria of whether it’s testable and practical. The class revises the question together until it is a testable question that meets the criteria. The revised question becomes the question that will be used for a class investigation. Students should record their work in their science notebook.  Students may come up with questions such as:   * How does changing the stride length impact speed in race walking? * How does leg length impact stride length in race walking?   How does change in footwear impact speed in race walking? | Teacher asks table teams to brainstorm a list of 2-3 investigable questions to vet. Teacher provides the criteria (previously modeled) and table teams discuss and analyze the worthiness of each of their questions.  Using numbered heads together, the table teams share their best question with the class, as well as their analysis of how it meets the ‘testable’ criteria. Teacher asks for further input or agreement from class.  Small groups/table teams select for their team investigation, one of the questions that met all the criteria. Students should record their work in their science notebook. | Students write their own focus question individually and determine how it meets the ‘testable’ criteria. The questions and rationales are displayed and critiqued by partners, table groups, or whole class.  After the feedback, the question is revised if necessary and becomes the focus question for the student’s personal investigation. Students should record their work in their science notebook. |
| **Additional scaffolds for diverse learners including Migrant/ELL students with multimodal supports**:  While explaining orally, (lecturing, demonstrating, etc.) use visual props such as realia, photos, sketching, cut out images, gestures, graphic organizers, charts, graphs, pictures, diagrams, maps, ect.., to aid understanding. Manipulate the visuals, as well as written words while discussing and critiquing the questions.  Stop every 10 minutes (or less depending on grade level) to provide students the time to digest the material and negotiate for meaning through paired partner sharing with a prompt.  When demonstrating how to ‘critique’ an investigable question, use tiered sentence structure as needed, providing some examples using simpler sentence structure, followed by examples using a more complex oral or written frame to support student understanding during the critique.  Examples include…   * Simple Language: I agree that… I disagree that… I thought that …. * Sufficient Language: I agree \_\_\_\_, but disagree \_\_\_\_..., I have a different idea, I think… * Sophisticated Language: A different way of thinking about the question is…, Have you considered…   Some vocabulary words may require direct instruction, but consider whether the visual scaffolding, oral patterning, and demonstration will help make some term(s) understood without direct instruction.  When a task requires **oral share out or oral discourse** of any kind, (such as asking the student to orally share out the investigable question, or a critique of the question), scaffold the process of oral production by starting with paired sharing in English, allowing the Migrant/ ELL student to go second giving him/her a chance to listen first. Follow the paired sharing with small group share out, and finally, whole class share out, praising comprehensible production even if only a word or phrase. If the ELL student is not yet at the developmental stage of beginning oral production in English, (which takes anywhere from 0-9 months), consider using some of the following options in place of oral English production to identify the student’s level of comprehension:   * Allow the student to use his/her primary language. * Allow the student to repeat aloud after a peer shares out sentences, phrases, or words. * Allow the student to point or answer a yes/no question to obtain level of understanding.   When a task requires **writing**, such as writing an investigable question or a written critique of a question), consider using some of the following writing options:   * Allow the manipulation of realia or graphics to state (write) the question. * Allow the student to sketch the question using graphics and words or labels. * Allow the student to write the question in his/her primary language (L1) moving to English when possible (This presumes the student can write in his/her primary language and knows the terminology needed to complete the task.) * Allow the student who is not yet writing to use L1 to verbally state their question or repeat after a partner states the question (telegraphic speech). * Provide the student a written frame to fill in (with words, sketches or graphics).   Choose focus questions that might tie into a migrant student’s experiences. Use cultural examples that migrant students might relate to such as indigenous peoples who have walked many miles barefoot (Incan messengers), and whether or not shoes may help or hinder their speed. | | |

|  |  |  |  |
| --- | --- | --- | --- |
| **Formulating Investigable Questions and Predictions** (continued) | | | |
|  | More Guided  **I DO**  Teacher demonstrates/models (whole class) | **WE DO**  Small groups/Table teams | More Open-Ended  **YOU DO**  Individuals |
| **Making Predictions**  A conditional statement focusing on what will happen as a result of conducting an investigation.  ***Criteria:***  *The prediction describes what would be a reasonable answer to the question.*  *The prediction includes “If \_\_\_, then \_\_\_\_, because \_\_\_\_” ideas.*  *The prediction is based on observations and scientific principles and not personal opinion.* | Teacher models verbally and in writing what “making a prediction” is. Teacher does a think aloud to explain how he/she makes a prediction. “If something occurs, what will happen? Why will it happen? What is the reason? Teacher introduces an “If/then/because” frame to support making a prediction. Teacher uses the prompt verbally and in writing (perhaps with graphics) to demonstrate the creation of a prediction with class. He/she then demonstrates how the question meets the criteria (at left) and whether or not it is a reasonable and scientific prediction. Students should record their work in their science notebook.  Sample prompt: “If we change the length of the stride, then what will happen?” (Write it out in words (using the sample if/then/because frame below) and sketch or use graphics to support concepts.) Example: “If we change the length of the stride in race walking, it will impact the speed. Is this a reasonable answer to our question? Is the ‘because’ based on my opinion, or is it based on a scientific principle that is related? What principle?”  Ask students to turn to their elbow partner to share how the class question meets the criteria. | Provide a written scaffold (frame) like the examples at left. Prompt table teams to work together to write a prediction to their focus question using the frame. Have them practice using the frame orally to share their prediction with another team, or the class.  Students should record their work in their science notebook. Students may also include drawings or sketches to illustrate their ideas. | Individual students write their prediction using the frame provided by the teacher. Eventually, students will have enough experience in making and writing predictions that the frame will no longer be needed. Students should record their work in their science notebook. |
| **Graphic Organizers:**  **Sample Prediction Frame**  If we \_\_(do this)\_\_\_, then \_\_\_\_\_(what will happen)\_\_\_\_\_, because \_\_\_\_\_\_. | | |
| **Additional scaffolds for Diverse Learners Including Migrant/ELL students with Multimodal Supports** :  For Migrant/ELL students, manipulate graphics (visual icons) as you model many oral predictions examples. Model multiple predictions using patterned speech, replacing only one word or phrase at a time. Support comprehension by manipulating meaningful graphics, or sketching while speaking.  In small groups or in pairs, allow Migrant/ELL students to verbalize their predictions and explanations using either L1/L2 prior to writing. Could use oral role play and even provide an oral frame to use if needed. Written predictions could start with simply copying a prediction from the board. It can proceed further with a sketch or the use of manipulative icons placed in a meaningful order to represent a prediction.  The writing continuum would proceed to the use of short phrases (broken English) that describes a prediction and move to more robust and complete sentences as the student gains more English proficiency. | | |

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| **Scaffolding the Inquiry Process: From Guided to Open-Ended** | | | |
| **Planning and Carrying Out Investigations** | | | |
|  | More Guided  **I DO**  Teacher demonstrates/models (whole class) | **WE DO**  Small groups/Table teams | More Open-Ended  **YOU DO**  Individuals |
| **Identifying and Defining Variables**  ***Criteria:***  *Investigation plan will include identifying the dependent, independent and controlled variables.* | Introduce the concept of “variable” by discussing with the class how to make this a fair test. Provide examples that are student centered such as a race from one point to another.  Ask the students to think about what would make a race unfair and list these “variables” on the board (i.e., different track lengths, tennis shoes versus high heels, one race track made of loose sand versus a track made of asphalt, or giving one person more time to run the track, etc.)  Review the class investigation question and prediction. Together, make a list of the variables involved in the investigation (i.e., time, track surface, track length, shoe type, etc.) Using a graphic organizer like one of the ones below, teacher does a think aloud with each variable and decides/models where in the organizer to place it. Teacher shares reasons for categorizing and move variables around the chart as needed. Students should record their work in their science notebook. | Student groups or partners collaboratively develop their own list of variables for their investigation and sort them into the teacher provided team organizer to determine which are the manipulated, controlled and responding variables are. The variables are then displayed publicly and critiqued by partners, table groups or whole class before proceeding with further team planning of the investigation. Students should record their work in their science notebook. | Students identify and label the variables for their own investigation and place them into the teacher provided graphic organizer. The variables are displayed publicly and then discussed and critiqued by partners, table groups, or whole class before proceeding with further planning of the investigation. Eventually, students will have enough experience in identifying variables that they will no longer need the graphic organizer. Students should record their work in their science notebook. |
| **Sample Graphic Organizer# 1:**   |  |  |  |  |  | | --- | --- | --- | --- | --- | | What should be changed?  (Manipulated variable(s)) |  |  | **Sample Graphic Organizer #2** | | | What should be kept the same?  (Controlled variable(s)) |  | Variable Changed: | Variable Kept the Same: | | What should be measured or observed?  (Responding variable(s)) |  | Variable measured or observed: | | | | |
| **Additional scaffolds for Diverse Learners Including Migrant/ELL students with Multimodal Supports** :  May need to build background on the word fair, as in a “fair test”. This can be done with lots of visual support and role play using realia (bring a pair of high heels and tennis shoes). Have students hold up a “fair” (green) card or an “unfair” (red) card when prompted after watching examples during the role play.  Vocabulary words (manipulated, controlled, responding variables) will likely be learned through the lesson activities with regular scaffolded use and emphasis. When brainstorming the list of variables that will be used for sorting, include a visual icon that represents each along with the abstract written (word) representation. Including graphic icons also on the organizer will help with comprehension and brain imprinting:   |  |  |  | | --- | --- | --- | | What should we **change**? Δ | What will we keep the same? = | What will we measure? |   Provide Migrant/ELL students the opportunity to share in pairs or small groups before having to share out in whole group. Provide alternatives when sharing out, (written or oral) such as the using L1, repeating English from peer, manipulating graphics to represent thought, sketching, role playing, filling in a frame with words or pictures, etc.  Make connections between the home and school through a ‘take home’ activity that may involve the student asking their parent, guardian or other adult in the household about an unfair experience and what may have been able to be ‘controlled’ for a more fair situation. | | |

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| **Planning and Carrying Out Investigations** | | | |
|  | More Guided  **I DO**  Teacher demonstrates/models (whole class) | **WE DO**  Small groups/Table teams | More Open-Ended  **YOU DO**  Individuals |
| **Writing the Procedure**  ***Criteria:***  *Procedure identifies independent, dependent and controlled variables.*  *Procedure identifies what tools are needed to gather the data.*  *Procedure states how the measurements will be recorded.*  *Procedure states how many data are needed to support a claim.* | Teacher demonstrates a direct connection of each variable with one or more procedural steps, showing a correspondence. Steps are written on strips of paper for re-ordering. Students practice mixing up and re-ordering the steps to correspond with the variables:   * What should be changed? * What should be kept the same? * How will the differences be measured or observed?   A graphic organizer (see example below) will support student comprehension of the order of the procedure and the correspondence of the steps to the variables.  Using numbered heads together, small groups of students suggest procedures that could be followed for the investigation.  Teachers write procedural steps on strips and placed into pocket chart. As a whole class, steps are critiqued and moved around pocket chart to correspond with variables listed on left.  Once consensus is reached, students write out the procedures to their investigation. Students should record their work in their science notebook. | Brainstorm together (small groups) a list of potential steps for the investigation. Write them on paper strips.  Have students place the investigation strips in chronological order. Then have them place the strips into the supporting graphic organizer to see if they need to change the order of the steps.  Students identify in the procedure which steps account for different variables. The order of the steps and the correspondence to the variables can be verified by another small group before proceeding with the investigation. Students should record their work in their science notebook. | Students independently write and order the procedural steps for own investigation. Students can orally identify and label which steps relate to each variable. Students should record their work in their science notebook. |
| **GRAPHIC ORGANIZER:**  Adding another column to the graphic organizer used to support the development of variables will support the understanding of connecting procedural steps to each variable.   |  |  |  | | --- | --- | --- | | **ASK STUDENTS:** | **POSSIBLE RESPONSES:** | **USE RESPONSES TO CREATE PROCEDURAL STEPS:** | | What should be changed?  (Manipulated variable here…) | Length of stride  (Short, medium, long) | 1. Choose one kind of stride (short, medium or long) to walk. | | What should be kept the same?  (Controlling variables here…) | Same person walking  Same surface  Same footwear  Same distance | 1. Walker should start at the starting point ready to walk. 2. Make sure the walker walks on the same path/surface wearing the same footwear. 3. Walker walks to the same ending point. | | How will the differences be measured or observed, and recorded?  (Responding variable here…) | Time to cover distance in seconds | 1. Measure the speed of the walker from the start to the end using a timer to the nearest tenth of a second. 2. Record the time to walk the distance in your data table | | | |
| **Additional scaffolds for diverse learners including Migrant/ELL students with multimodal supports:**  Use visuals to support words in graphic organizer.  Scaffold any oral discussion by starting with partner sharing, moving to small group sharing, then whole group sharing. Allow use of L1, sketching thoughts, repeating in English with support from partner, acting out physically, etc. | | |

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| **Planning and Carrying Out Investigations (continued)** | | | | |
|  | More Guided  **I DO**  Teacher demonstrates/models (whole class) | **WE DO**  Small groups/Table teams | | More Open-Ended  **YOU DO**  Individuals |
| **Collecting Data**  ***Criteria:***  *The data collection device has a title, is clearly labeled, and has enough room to record the data.* | Teachers create a class data chart for students to record individual or group observations or data.  Students recreate their data chart from the class chart.  Teachers work with the class to develop a data table or other collection device. Questions to support development of data or observation charts could include…   * What information are we collecting? * How many trials of each should we include? * Do we need to average any data? * What would our chart look like? * What is the title of our table or chart?   Students should record their work in their science notebook. | Teachers either provide or prompt students to create (in small groups) a variety of data collection devices such as a data table or chart.  Variations of data tables or charts among small groups are discussed and critiqued and the class chooses a single data collection device, or the class modifies several possible collection devices to create a class data table or chart.  Students should record their work in their science notebook. | | Students create their own data collection device which will be displayed and critiqued by classmates. They share their rationale for their data collection device and request feedback from a partner or table group team.  Students should record their work in their science notebook. |
| **Additional scaffolds for diverse learners including Migrant/ELL students with multimodal supports:**  Create Class Input Chart (Data Table) with along with steps and labels that can be left up as a resource for students. (See examples below.) Steps include…  **Step One**: Creating a title that includes the data being displayed.  **Step Two**: Cover as much space as possible with in the graph for plotted data. Leave enough space along the axes for labels, even scale divisions, units of measures.  **Step Three**: Label both horizontal (x axis-independent/manipulated/changed variable) and vertical (y axis-dependent/responding/measured or observed variable) with descriptions and units of measure.  **Step Four**: Set the scale for each axis. Look for your highest measured value and make sure it fits on your table. Create equal increments on your scale to meet that highest value.  **Step Five**: Make the scaling of each axis start at zero.  **Step Six**: Plot the location of each data point on the graph with a small dot.  **Step Seven**: To account for natural variability, put a small circle around each data value plotted on the graph. Do not connect dots rather use straight or curved lines. | | | |
| **Well-Constructed Example**  By looking at the title and labels someone could see a picture that is happening over time.  Notice that dots are not connected, but with a straight line you can see a trend of what is happening as speed increases**.** | | http://misterguch.brinkster.net/graph2.gif | |
| **Poorly-Constructed Example**  Someone looking at this graph would not be able to understand the information put on the graph even though it is the same information as the graph above. This graph includes…   * No Title * No Labels * No Units * Connected Dots | | http://misterguch.brinkster.net/graph1.gif | |

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| **Scaffolding the Inquiry Process: From Guided to Open-Ended** | | | | | |
| **Constructing Explanations** | | | | | |
|  | More Guided  **I DO**  Teacher demonstrates/models (whole class) | | **WE DO**  Small groups/Table teams | More Open-Ended  **YOU DO**  Individuals | |
| **Making a Claim**  ***Criteria:***  *The explanation uses evidence such as measurements, observations, and patterns, to support it.* | Teacher models the data analysis through the following steps:   1. Teacher uses the data table and does an oral ‘table walk/table talk’. Pointing to one piece of data in the data table, teacher makes oral statements (observable, quantifiable evidence statements) about the data.   *“Sample walker number one had a longer stride than sample walker number 2.*  *“Sample walker number one walked faster than sample walker number 2.”*  *“Sample walker number one finished the test walk in 5 minutes, whereas sample walker number 2 finished the test in 5.5 minutes.”*   1. Teacher writes the data statements on the board using patterned writing. 2. After reviewing several statements through a think-aloud, the teacher creates a claim and writes it in the “claims” column of a claims and evidence chart like the sample chart below. Use the frame “I claim that… “ Example: “I claim that the longer a person’s stride, the faster they can race walk.” 3. After writing the claim in the claims box, the teacher asks the question “How do I know this?” 4. Teacher does another think-aloud and points to evidence from the data table that supports his/her claim. The teacher writes the evidence statement in the “evidence” column of the claims and evidence chart. (See sample chart below.) Example: “I know this because the three test walkers with the longest strides walked an average of five minutes faster than the rest of the walkers.” The teacher can also model combining the claim and evidence statements together with the word “**because**” to make one complete claim and evidence statement. Students should record their work in their science notebook. | Teacher provides table teams a claims and evidence chart and prompts them to make a claim and support it with evidence, getting feedback from their table team peers on the validity of the claim. Data table (to reference for evidence) is posted in room where all can see.  Give table groups large pieces of chart paper and markers to make and display their claims and evidence chart. This makes it easier to share ideas and get feedback between groups. It also makes the thinking more of the whole group and less of one individual which allows for more effective discourse of ideas.  Students should record their work in their science notebook. | | | Teacher prompts individuals to review their data, and write a claims and evidence statement to share with partners or small groups. Teacher may provide a claims and evidence chart if needed, but eventually the students will not need the graphic organizer support, as they will be able to create their own.  Students are able to independently review a data table, make a claim, and support it with evidence. They are able to write claims statements in claims and evidence charts and show a one-to-one correspondence with the evidence that supports their claim.  Students should record their work in their science notebook. |
| **Additional scaffolds for diverse learners including Migrant/ELL students with multimodal supports:**   |  |  | | --- | --- | | Claim and Evidence Example | | | My question… | | | I claim that… | I know this because  … |   Have students use the following prompts to discuss the data table with the class or small groups:  I noticed…, I observed… I think…  In my opinion…, One idea is…,  I think it is interesting that…  Something that caught my attention was…, Another way to think about it is…  Write some claims statements and some evidence statements on sentence strips and having teams sort them into a claims pile and an evidence pile. Add the word “because” on a separate strip and have students manipulate the strips to practice combining one claim strip with the word because and one evidence strip and reading sentence aloud.  Create Class Input Chart (Claim and Evidence Chart) to assist students in organizing their understanding. See example to the side… | | | | |

Scaffolding the Inquiry Process: From Guided to Open Ended Appendix L (continued)

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| **Scaffolding the Inquiry Process: From Guided to Open-Ended** | | | |
| **Engaging in Argument from Evidence** | | | |
|  | More Guided  **I DO**  Teacher demonstrates/models (whole class) | **WE DO**  Small groups/Table teams | More Open-Ended  **YOU DO**  Individuals |
| **Communicating your explanation and reasoning:--**Bringing it all together  ***Criteria:***  *The argument (claim) is supported by evidence (data) and scientific reasoning.* | Teacher uses the charts on the wall and conducts a walk through review of the inquiry question, the possible predictions, the selected prediction, the data chart (where evidence was gathered) and the written claim and evidence statement together and then asks, “So what is our scientific conclusion?”  Through a think-aloud, and using the writing frame below as a guide, the teacher models scientific reasoning and the development of a scientific conclusion.  Class discusses the positive attributes of the teacher’s scientific conclusions.  Groups can then go back to edit/revise their scientific conclusions.  Scaffold (Chart Below) is made public as a chart in the classroom. Students should record their work in their science notebook. | Teacher provides the prompt of an inquiry question and the scientific reasoning writing frame is publicly displayed on the wall.  Small groups work together to develop a scientific conclusion that includes the following:   * Question and hypothesis/prediction * Answer to prediction (linking claim and evidence together) * Scientific conclusion/justification * Follow up questions   Work is made public on chart paper where other groups give feedback on the conclusion.  Class discussion regarding the positive attributes of each group’s conclusions.  Groups can then go back to edit/revise.  Students should record their work in their science notebook. Students publicly present their findings to their peers. | Students individually bring together their inquiry question, their prediction, claims, and evidence and develop a conclusion/reason.  Students should record their work in their science notebook. Students publicly present their findings to their peers. |
| **Additional scaffolds for diverse learners including Migrant/ELL students with multimodal supports:**   |  | | --- | | **Writing Frame Example to Support Scientific Reasoning:** | | I wanted to know \_\_\_\_\_\_(question)\_\_\_\_\_\_\_\_\_\_\_\_\_. | | At first I thought \_\_\_\_\_\_ (prediction/hypothesis)\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. | | I found that \_\_\_\_\_\_\_(claim)\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ because \_\_\_\_\_(evidence)\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. | | So now I know that \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. (Or) So I conclude that \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. | | A question that still remains unanswered is \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. |   Use scaffold as model for students to follow to integrate the important components of a scientific conclusion. | | |

Assessment Rubric (Student Friendly)

**Asking Questions Rubric:**

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| **Asking Questions** | |
| One Point | With support of my class, small group or individually I can identify a testable questions that requires sufficient and appropriate empirical evidence (evidence gathered through observations or measurements) to answer.   * I can tell the difference between a question that can be tested rather than a question answered through research * The question I chose from a list is testable and can be answered through scientific investigations |
| Two Points | With support of the class or small group I can develop a testable question that requires sufficient and appropriate empirical evidence (evidence gathered through observations or measurements) to answer. My question would include…   * A scientific question can be answered through a scientific investigation * A scientific question that requires either observable data or numerical data to answer |
| Three Points | Independently I can develop a testable question that requires sufficient and appropriate empirical evidence (evidence gathered through observations or measurements) to answer. My question would include…   * A scientific question can be answered through a scientific investigation * A scientific question that requires either observable data or numerical data to answer |
| My Score… | What I did well…  What I can do to improve my ability to ask a testable question… |

Appendix M

**Asking Questions Rubric:**

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| **Asking Questions** | |
| One Point | With support of my class, small group or individually I can identify a testable questions that requires sufficient and appropriate empirical evidence (evidence gathered through observations or measurements) to answer.   * I can tell the difference between a question that can be tested rather than a question answered through research * The question I chose from a list is testable and can be answered through scientific investigations |
| Two Points | With support of the class or small group I can develop a testable question that requires sufficient and appropriate empirical evidence (evidence gathered through observations or measurements) to answer. My question would include…   * A scientific question can be answered through a scientific investigation * A scientific question that requires either observable data or numerical data to answer |
| Three Points | Independently I can develop a testable question that requires sufficient and appropriate empirical evidence (evidence gathered through observations or measurements) to answer. My question would include…   * A scientific question can be answered through a scientific investigation * A scientific question that requires either observable data or numerical data to answer |
| My Score… | What I did well…  What I can do to improve my ability to ask a testable question… |

**Making Predictions Rubric**

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| **Making Predictions** | |
| One Point | With support of my class, small group or individually I can write a prediction that includes…   * If… A statement of what I will test * Then... A statement of what will happen * Because… A statement with of why I believe what will happen based on my **personal experiences** |
| Two Points | With support of the class or my group I can write a prediction that includes…   * If… A statement of what I will test * Then... A statement of what will happen * Because… A statement with **scientific reasoning** of why I believe what will happen |
| Three Points | Independently I can write a prediction that includes…   * If… A statement of what I will test * Then... A statement of what will happen * Because… A statement with **scientific reasoning** of why I believe what will happen |
| My Score… | What I did well…  What I can do to improve my ability to make a prediction… |

**Making Predictions Rubric**

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| **Making Predictions** | |
| One Point | With support of my class, small group or individually I can write a prediction that includes…   * If… A statement of what I will test * Then... A statement of what will happen * Because… A statement with of why I believe what will happen based on my **personal experiences** |
| Two Points | With support of the class or my group I can write a prediction that includes…   * If… A statement of what I will test * Then... A statement of what will happen * Because… A statement with **scientific reasoning** of why I believe what will happen |
| Three Points | Independently I can write a prediction that includes…   * If… A statement of what I will test * Then... A statement of what will happen * Because… A statement with **scientific reasoning** of why I believe what will happen |
| My Score… | What I did well…  What I can do to improve my ability to make a prediction… |

**Identifying Variables Rubric**

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| **Identifying and Defining Variables** | |
| One Point | With support of my class, small group or individually I can In my investigation I can correctly identify and communicate…   * Some of the controlled variables * Identify either the Independent or Dependent Variable, but not both |
| Two Points | With the support of the class or small group I can correctly identify and communicate…   * A list of controls in the investigation * The independent or manipulated (changed) variable * The dependent or responding (measured or observed) variable |
| Three Points | Independently I can correctly identify and communicate…   * A list of controls in the investigation * The independent or manipulated (changed) variable * The dependent or responding (measured or observed) variable |
| My Score… | What I did well…  What I can do to improve… |

**Identifying Variables Rubric**

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| **Identifying and Defining Variables** | |
| One Point | With support of my class, small group or individually I can In my investigation I can correctly identify and communicate…   * Some of the controlled variables * Identify either the Independent or Dependent Variable, but not both |
| Two Points | With the support of the class or small group I can correctly identify and communicate…   * A list of controls in the investigation * The independent or manipulated (changed) variable * The dependent or responding (measured or observed) variable |
| Three Points | Independently I can correctly identify and communicate…   * A list of controls in the investigation * The independent or manipulated (changed) variable * The dependent or responding (measured or observed) variable |
| My Score… | What I did well…  What I can do to improve… |

**Planning and Carrying Out Investigations:**

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| **Writing Procedures Rubric** | |
| One Point | With support from the class or small group *order the procedural steps* for an investigation that include the following:   * Logical steps that can be followed by others * Steps include controlled, dependent and independent variables * Tools and materials to carry out investigation * What data needs to be gathered * How and where to record data * How many times investigation should be conducted (multiple trials) |
| Two Points | With support from the class or small group *write/communicate and order the procedural steps* for an investigation that include the following:   * Logical steps that can be followed by others * Steps include controlled, dependent and independent variables * Tools and materials to carry out investigation * What data needs to be gathered * How and where to record data * How many times investigation should be conducted (multiple trials) |
| Three Points | Independently write/communicate and order the procedural steps for an investigation that include all the following:   * Logical steps that can be followed by others * Steps include controlled, dependent and independent variables * Tools and materials to carry out investigation * What data needs to be gathered * How and where to record data * How many times investigation should be conducted (multiple trials) |
|  | Independently write/communicate and order the procedural steps for an investigation that include the following:   * Logical steps that can be followed by others * Steps include controlled, dependent and independent variables * Tools and materials to carry out investigation * What data needs to be gathered * How and where to record data * How many times investigation should be conducted (multiple trials)   After investigation revise/edit/evaluate procedures to ensure quality of investigation |
| My Score… | What I did well…  What I can do to improve… |

**Planning and Carrying Out Investigations:**

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| **Writing Procedures Rubric** | |
| One Point | With support from the class or small group *order the procedural steps* for an investigation that include the following:   * Logical steps that can be followed by others * Steps include controlled, dependent and independent variables * Tools and materials to carry out investigation * What data needs to be gathered * How and where to record data * How many times investigation should be conducted (multiple trials) |
| Two Points | With support from the class or small group *write/communicate and order the procedural steps* for an investigation that include the following:   * Logical steps that can be followed by others * Steps include controlled, dependent and independent variables * Tools and materials to carry out investigation * What data needs to be gathered * How and where to record data * How many times investigation should be conducted (multiple trials) |
| Three Points | Independently write/communicate and order the procedural steps for an investigation that include all the following:   * Logical steps that can be followed by others * Steps include controlled, dependent and independent variables * Tools and materials to carry out investigation * What data needs to be gathered * How and where to record data * How many times investigation should be conducted (multiple trials) |
|  | Independently write/communicate and order the procedural steps for an investigation that include the following:   * Logical steps that can be followed by others * Steps include controlled, dependent and independent variables * Tools and materials to carry out investigation * What data needs to be gathered * How and where to record data * How many times investigation should be conducted (multiple trials)   After investigation revise/edit/evaluate procedures to ensure quality of investigation |
| My Score… | What I did well…  What I can do to improve … |

**Planning and Carrying Out Investigations**

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| **Collecting Data Rubric** | |
| One Point | With support from the class, small group or independently I can construct a tool/table to collect data from investigation.  Tool/Table includes *some but not all* of the following:   * Labels/Units of Measurements * Title that represents investigation * Data from Multiple Trials * Averaged Data if Applicable |
| Two Points | With support from the class or small group I can construct a tool/table to collect data from investigation.  Tool/Table should include *all* of the following:   * Labels/Units of Measurements * Title that represents investigation * Data from Multiple Trials * Averaged Data if Applicable |
| Three Points | Independently construct a tool/table to collect data from investigation.  Tool/Table should include *all* of the following:   * Labels/Units of Measurements * Title that represents investigation * Data from Multiple Trials * Averaged Data if Applicable |
| My Score… | What I did well…  What I can do to improve… |

**Planning and Carrying Out Investigations**

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| **Collecting Data Rubric** | |
| One Point | With support from the class, small group or independently I can construct a tool/table to collect data from investigation.  Tool/Table includes *some but not all* of the following:   * Labels/Units of Measurements * Title that represents investigation * Data from Multiple Trials * Averaged Data if Applicable |
| Two Points | With support from the class or small group I can construct a tool/table to collect data from investigation.  Tool/Table should include *all* of the following:   * Labels/Units of Measurements * Title that represents investigation * Data from Multiple Trials * Averaged Data if Applicable |
| Three Points | Independently construct a tool/table to collect data from investigation.  Tool/Table should include *all* of the following:   * Labels/Units of Measurements * Title that represents investigation * Data from Multiple Trials * Averaged Data if Applicable |
| My Score… | What I did well…  What I can do to improve… |

**Constructing Explanations**

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| **Making Claims Rubric** | |
| One Point | With support from class, small groups or individually …   * I made a claim based on the investigation but have no evidence to support that claim, or… * I made a claim but based that claim on personal experience rather than evidence from investigation, or… * I provided data as evidence, but did not make a claim about what that data point means. |
| Two Points | With support from class or small groups …   * I made a claim and was able to back that claim up with empirical (measured or observable) data from the investigation. |
| Three Points | Independently…   * I made a claim and was able to back that claim up with empirical (measured or observable) data from the investigation. |
| My Score… | What I did well…  What I can do to improve… |

**Constructing Explanations**

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| **Making Claims Rubric** | |
| One Point | With support from class, small groups or individually …   * I made a claim based on the investigation but have no evidence to support that claim, or… * I made a claim but based that claim on personal experience rather than evidence from investigation, or… * I provided data as evidence, but did not make a claim about what that data point means. |
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| Three Points | Independently…   * I made a claim and was able to back that claim up with empirical (measured or observable) data from the investigation. |
| My Score… | What I did well…  What I can do to improve… |

**Constructing Explanations**

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| **Communicating Reasoning Rubric** | |
| One Point | With support from class, small groups or individually I bring my thinking together using *some* of the following to develop a scientific conclusion:   * Inquiry Question * Prediction * Claims and Evidence * Scientific Reasoning |
| Two Points | With support from class, small groups or individually I bring my thinking together using *all of* the following to develop a scientific conclusion:   * Inquiry Question * Prediction * Claims and Evidence   Scientific Reasoning |
| Three Points | Independently I bring my thinking together using *all of* the following to develop a scientific conclusion:   * Inquiry Question * Prediction * Claims and Evidence   Scientific Reasoning |
| My Score… | What I did well…  What I can do to improve… |

**Constructing Explanations**

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| **Communicating Reasoning** | |
| One Point | With support from class, small groups or individually I bring my thinking together using *some* of the following to develop a scientific conclusion:   * Inquiry Question * Prediction * Claims and Evidence * Scientific Reasoning |
| Two Points | With support from class, small groups or individually I bring my thinking together using *all of* the following to develop a scientific conclusion:   * Inquiry Question * Prediction * Claims and Evidence   Scientific Reasoning |
| Three Points | Independently I bring my thinking together using *all of* the following to develop a scientific conclusion:   * Inquiry Question * Prediction * Claims and Evidence   Scientific Reasoning |
| My Score… | What I did well…  What I can do to improve… |

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| Assessment Rubric (Teacher) Appendix N | | | | |
|  | 1 Point | 2 Points | 3 Points | **4 Points** |
| **Asking Questions and Defining Problems** | With support of my class, small group or individually I can identify a testable questions that requires sufficient and appropriate empirical evidence (evidence gathered through observations or measurements) to answer.   * I can tell the difference between a question that can be tested rather than a question answered through research * The question I chose from a list is testable and can be answered through scientific investigations | With support of the class or small group I can develop a testable question that requires sufficient and appropriate empirical evidence (evidence gathered through observations or measurements) to answer. My question would include…   * A scientific question can be answered through a scientific investigation * A scientific question that requires either observable data or numerical data to answer | Independently I can develop a testable question that requires sufficient and appropriate empirical evidence (evidence gathered through observations or measurements) to answer. My question would include…   * A scientific question can be answered through a scientific investigation * A scientific question that requires either observable data or numerical data to answer |  |

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| --- | --- | --- | --- | --- |
|  | **1 Point** | **2 Points** | **3 Points** | **4 Points** |
| **Making Predictions** | With support of my class, small group or individually I can write a prediction that includes…   * If… A statement of what I will test * Then... A statement of what will happen * Because… A statement with of why I believe what will happen based on my **personal experiences** | With support of the class or my group I can write a prediction that includes…   * If… A statement of what I will test * Then... A statement of what will happen * Because… A statement with **scientific reasoning** of why I believe what will happen | Independently I can write a prediction that includes…   * If… A statement of what I will test * Then... A statement of what will happen * Because… A statement with **scientific reasoning** of why I believe what will happen |  |

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| --- | --- | --- | --- | --- |
|  | **1 Point** | **2 Points** | **3 Points** | **4 Points** |
| **Planning and Carrying Out Investigations** | | | | |
| 1. **Identifying and Defining Variables** | With support of my class, small group or individually I can In my investigation I can correctly identify and communicate…   * Some of the controlled variables * Identify either the Independent or Dependent Variable, but not both | With the support of the class or small group I can correctly identify and communicate…   * A list of controls in the investigation * The independent or manipulated (changed) variable * The dependent or responding (measured or observed) variable | Independently I can correctly identify and communicate…   * A list of controls in the investigation * The independent or manipulated (changed) variable * The dependent or responding (measured or observed) variable |  |
| 1. **Writing the Procedure** | With support from the class or small group *order the procedural steps* for an investigation that include the following:   * Logical steps that can be followed by others * Steps include controlled, dependent and independent variables * Tools and materials to carry out investigation * What data needs to be gathered * How and where to record data * How many times investigation should be conducted (multiple trials) | With support from the class or small group *write/communicate and order the procedural steps* for an investigation that include the following:   * Logical steps that can be followed by others * Steps include controlled, dependent and independent variables * Tools and materials to carry out investigation * What data needs to be gathered * How and where to record data * How many times investigation should be conducted (multiple trials) | Independently write/communicate and order the procedural steps for an investigation that include all the following:   * Logical steps that can be followed by others * Steps include controlled, dependent and independent variables * Tools and materials to carry out investigation * What data needs to be gathered * How and where to record data * How many times investigation should be conducted (multiple trials) | Independently write/communicate and order the procedural steps for an investigation that include the following:   * Logical steps that can be followed by others * Steps include controlled, dependent and independent variables * Tools and materials to carry out investigation * What data needs to be gathered * How and where to record data * How many times investigation should be conducted (multiple trials)   After investigation revise/edit/evaluate procedures to ensure quality of investigation |
| 1. **Collecting Data** | With support from the class, small group or independently I can construct a tool/table to collect data from investigation.  Tool/Table includes *some but not all* of the following:   * Labels/Units of Measurements * Title that represents investigation * Data from Multiple Trials * Averaged Data if Applicable | With support from the class or small group I can construct a tool/table to collect data from investigation.  Tool/Table should include *all* of the following:   * Labels/Units of Measurements * Title that represents investigation * Data from Multiple Trials * Averaged Data if Applicable | Independently construct a tool/table to collect data from investigation.  Tool/Table should include *all* of the following:   * Labels/Units of Measurements * Title that represents investigation * Data from Multiple Trials * Averaged Data if Applicable |  |

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|  | **1 Point** | **2 Points** | **3 Points** | **4 Points** |
| **Constructing Explanations** | | | | |
| 1. **Making Claims and Using Evidence** | With support from class, small groups or individually …   * I made a claim based on the investigation but have no evidence to support that claim, or… * I made a claim but based that claim on personal experience rather than evidence from investigation, or… * I provided data as evidence, but did not make a claim about what that data point means. | With support from class or small groups …   * I made a claim and was able to back that claim up with empirical (measured or observable) data from the investigation. | Independently…   * I made a claim and was able to back that claim up with empirical (measured or observable) data from the investigation. |  |
| 1. **Communicating Reasoning** | With support from class, small groups or individually I bring my thinking together using *some* of the following to develop a scientific conclusion:   * Inquiry Question * Prediction * Claims and Evidence * Scientific Reasoning | With support from class, small groups or individually I bring my thinking together using *all of* the following to develop a scientific conclusion:   * Inquiry Question * Prediction * Claims and Evidence * Scientific Reasoning | Independently I bring my thinking together using *all of* the following to develop a scientific conclusion:   * Inquiry Question * Prediction * Claims and Evidence * Scientific Reasoning |  |

**Science Notebooks Appendix 0**

*As teachers involve students in inquiry-based science investigations, the need to communicate science learning in new ways has become evident. If students are encouraged to communicate their understanding of concepts through science notebook writings, these notebooks can be an effective strategy to help students learn science. Research has shown that science notebook writing may also be a way for students to strengthen their language skills as they develop an understanding of the world around them. Science notebooks allow teachers to assess students' understanding and provide the feedback students need for improving their performance.*

*Science notebooks contain information about the students' classroom experiences and are encouraged to use them as scientists would, before, during, and after all investigations. They are a place where students formulate and record their questions, make predictions, record data, procedures, and results, compose reflections, and communicate findings. Most importantly, notebooks provide a place for students to record new concepts they have learned.*

*-http://www.sciencenotebooks.org/notebookFeatures/*

Suggested Student Notebook Tabs

1. Table of Contents
2. Vocabulary
3. Develop a Testable Question
4. Making Predictions
5. Identify and Define the Variables
6. Writing the Procedure
7. Collecting Data
8. Making a Claim
9. Communicating Explanation and Reasoning