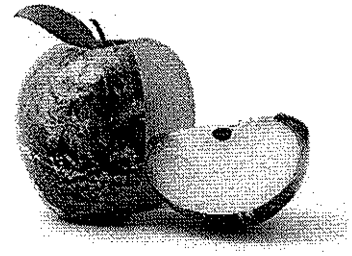


Miami-Dade County Public Schools
Office of Academics and Transformation
Department of Mathematics and Science

Science Leaders and Coaches Discourse: Middle School Science

Facilitator: Yoly McCarthy, Instructional Supervisor
Dane Jaber, Curriculum Support Specialist

8:30 – 9:00	Welcome and introductions/ materials share
9:00 – 10:00	Learning Goal use in Middle School Science (Group Activity) ▪ *Task directed Activity* • *Guiding Question* • *Where does it belong?*
10:00-10:15	Fisher science Education Steve Seinfeld
10:15-10:30	Karla Utting, *PhD, LEED Green Associate* Programs Director ***Dream in Green***
10:30– 10:45	BREAK
10:45-11:30	Middle School Science Updates • *STEM Tips Jennifer Diaz, Curriculum Support: new Teachers* • *Edgenuity (remediation component)* • *Data analysis use/ Thinkgate* • *Data trends for benchmarks/ Progress Monitoring tool*
11:30 – 12:30	Lunch
12:30 – 1:00	Competitions Updates (*Future City, eCyberMission, Florida Science Olympiad, STEM Expo dates, SECME updates)*
1:00 – 2:00	Common Core Standards: • *General info/ updates* • *Scavenger Hunt (What applies to science?)* • *Argumentation as a tool ("Science Teacher" Article)*
2:00-2:15	BREAK
2:15 –3:15	Differentiated Instruction in Science • *Steinberg's Intelligences*
3:15 – 3:30	Reflections

Follow up: (Due Wednesday, 11/22/13)
1. One page reflection of the workshop submitted on a designated collaboration site.
2. Evidence of the use of a learning goal for planning with other science teachers for the science classroom and a student work sample for evidence submitted on a designated collaboration site. i.e.: agenda, reflections, etc.
*All assignments must be submitted to EdModo "2013-2014 Middle Grades SCIENCE Leaders". The code to join is: **9hab2h**

MIAMI-DADE COUNTY PUBLIC SCHOOLS
SCIENCE-TECHNOLOGY-ENGINEERING-MATHEMATICS

Learning Goal use in Middle School Science

- *Task directed Activity*
- *Guiding Question*
- *Where does it belong?*

SC.6.P.13.3 Investigate and describe that an unbalanced force acting on an object changes its speed, or direction of motion, or both.

Scale	Learning Progression	Sample Progress Monitoring and Assessment Activities
Score/Step 5.0	☐ I am able to analyze observations and investigations to determine when forces acting on an object change its speed and/or direction.	
Score/Step 4.0	☐ I am able to evaluate how unbalanced forces acting on an object, changes its speed and/or direction.	
Score/Step 3.0 Target (Learning Goal)	☐ I am able recognize that an unbalanced force acting on an object changes its speed and/or direction.	
Score/Step 2.0	☐ I am able to recognize that an unbalanced force acting on an object changes its speed and/or direction	
Score/Step 1.0	☐ I am able to recognize forces and unbalanced forces.	

SC.7.E.6.4: Explain and give examples of how physical evidence supports scientific theories that Earth has evolved over geologic time due to natural processes. (Level 3: Strategic Thinking & Complex Reasoning)		
Scale	**Learning Progression**	**Sample Progress Monitoring and Assessment Activities**
Score/Step 5.0	☐ I am able to evaluate physical evidence to determine if it supports scientific theories that Earth has evolved, including scientific methods for measuring geologic time.	
Score/Step 4.0	☐ I am able to evaluate physical evidence to determine if it supports scientific theories that Earth has evolved, including scientific methods for measuring geologic time;	
Score/Step 3.0 Target (Learning Goal)	☐ I am able to interpret physical evidence that supports scientific theories that Earth has evolved, including scientific methods for measuring geologic time.	
Score/Step 2.0	☐ I am able to recognize that Earth has evolved over geologic time	
Score/Step 1.0	☐ I am able to describe the basic differences between physical weathering (breaking down of rock by wind, water, ice, temperature change, and plants) and erosion (movement of rock by gravity, wind, water, and ice).	

SC.7.E.6.4: Explain and give examples of how physical evidence supports scientific theories that Earth has evolved over geologic time due to natural processes. (Level 3: Strategic Thinking & Complex Reasoning)

Scale	Learning Progression	Sample Progress Monitoring and Assessment Activities
Score/Step 5.0	☐ I am able to evaluate physical evidence to determine if it supports scientific theories that Earth has evolved, including scientific methods for measuring geologic time.	
Score/Step 4.0	☐ I am able to evaluate physical evidence to determine if it supports scientific theories that Earth has evolved, including scientific methods for measuring geologic time;	
Score/Step 3.0 Target (Learning Goal)	☐ I am able to interpret physical evidence that supports scientific theories that Earth has evolved, including scientific methods for measuring geologic time.	
Score/Step 2.0	☐ I am able to recognize that Earth has evolved over geologic time	
Score/Step 1.0	☐ I am able to describe the basic differences between physical weathering (breaking down of rock by wind, water, ice, temperature change, and plants) and erosion (movement of rock by gravity, wind, water, and ice).	

Notes on Presentations (Fisher, Dream in Green)

Fisher Science Education

Steve Steinfeld
125 Yale Drive
Lake worth, FL 33460

561-889-3980
Steven.steinfeld@thermofisher.com

www.fisheredu.com

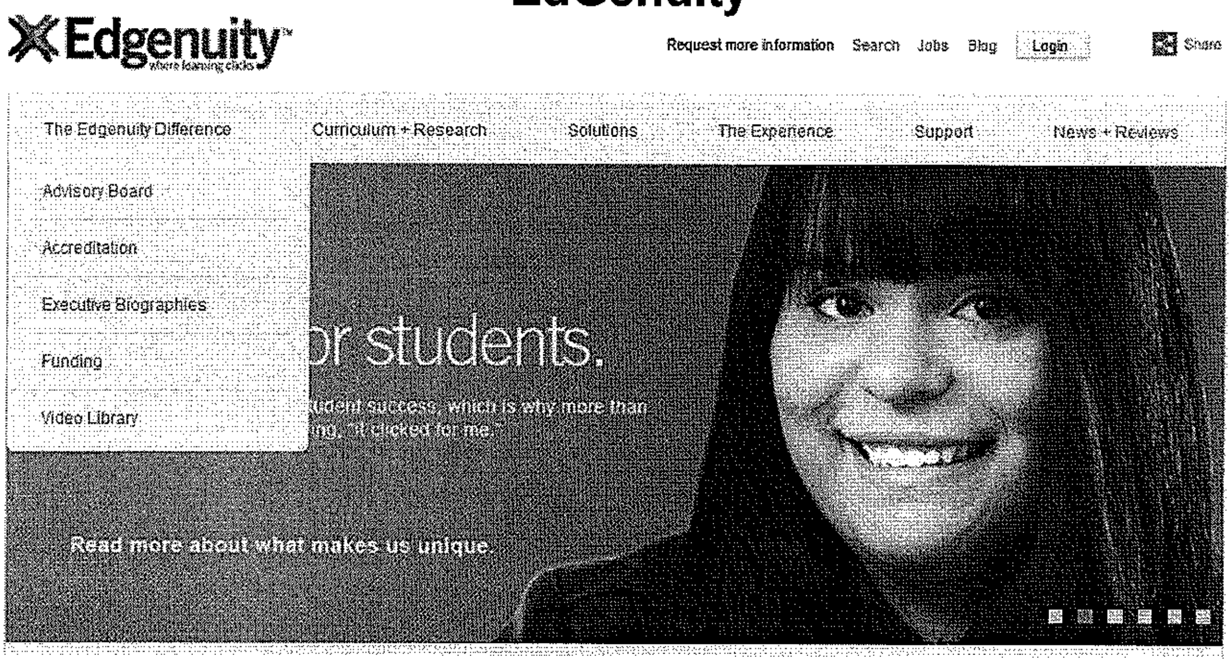
Dream in Green

Karla Utting, *PhD, LEED Green Associate*
Programs Director
Dream in Green
3000 Biscayne Blvd. Ste. 211, Miami, FL 33137
Tel: 305-576-3500
Fax:786-472-4128
www.dreamingreen.org
www.facebook.com/dreamingreen
www.twitter.com/Dream_in_Green

Middle School Updates: Notes

STEM Tips
Jennifer Diaz, Curriculum support
New Teachers

EdGenuity



- **Formerly e2020**
- **Similar to course recovery program**
- **Will be offered as three different courses**
- **Can be assigned by benchmarks according to interim or quarterly data**
- **Digital double dose**
- **Remediation and differentiation**
- **Available to all be the end of November**

Middle School Updates: Notes

thinkgate

unlocking intelligent decisions

MDCPS Thinkgate URL

http://www.thinkgate.net/FLMiamiDadeSplash/TGLogin.aspx

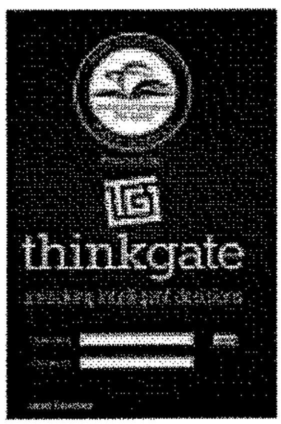
Logging In to Thinkgate

Below is the information needed for you to access your Thinkgate platform.

Be sure to turn off your pop-up blocker BEFORE attempting to login!

When logging in you will have 3 attempts. After 3 unsuccessful attempts, you will be locked out of the system and will need a district or school Thinkgate administrator to allow you login access.

MDCPS Login Screen



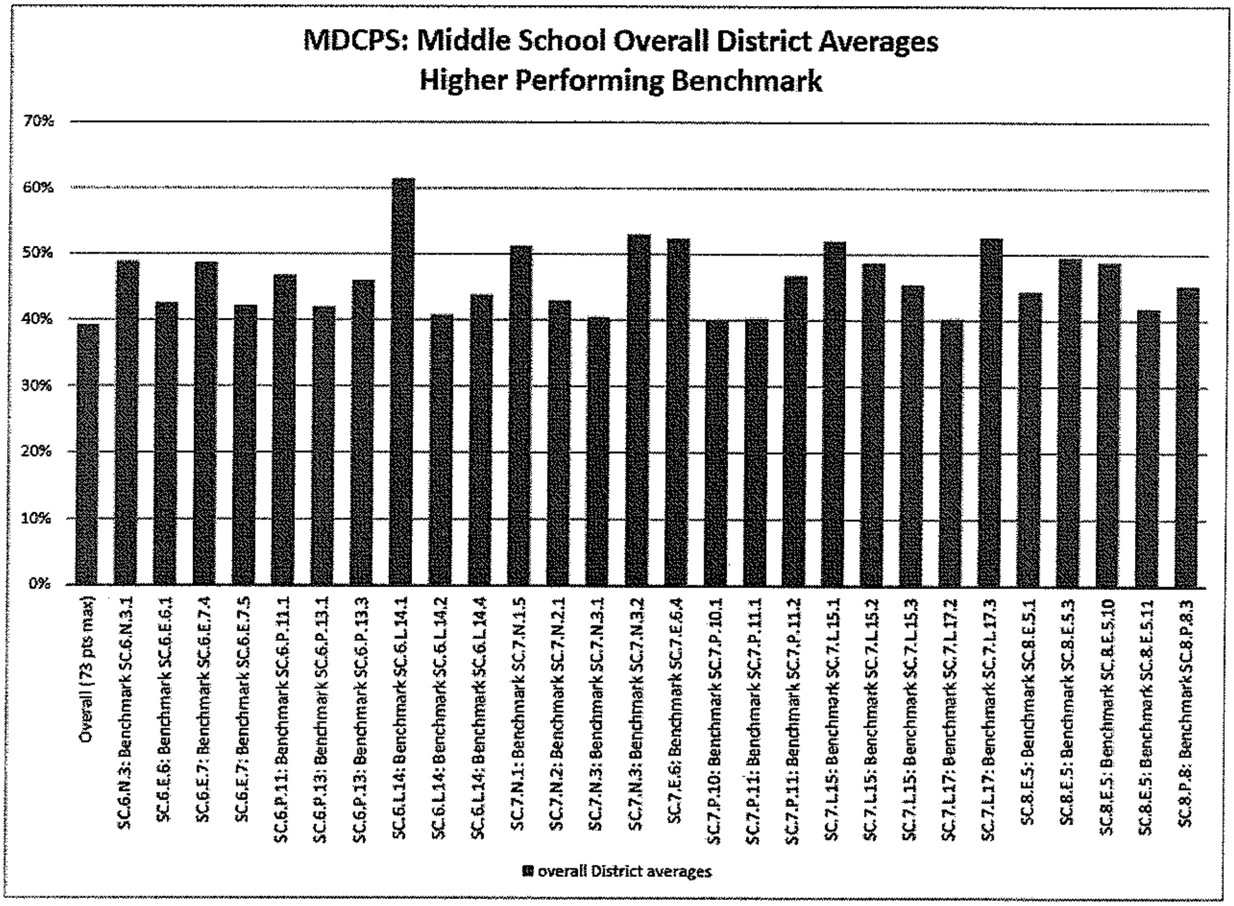
Login Instructions:

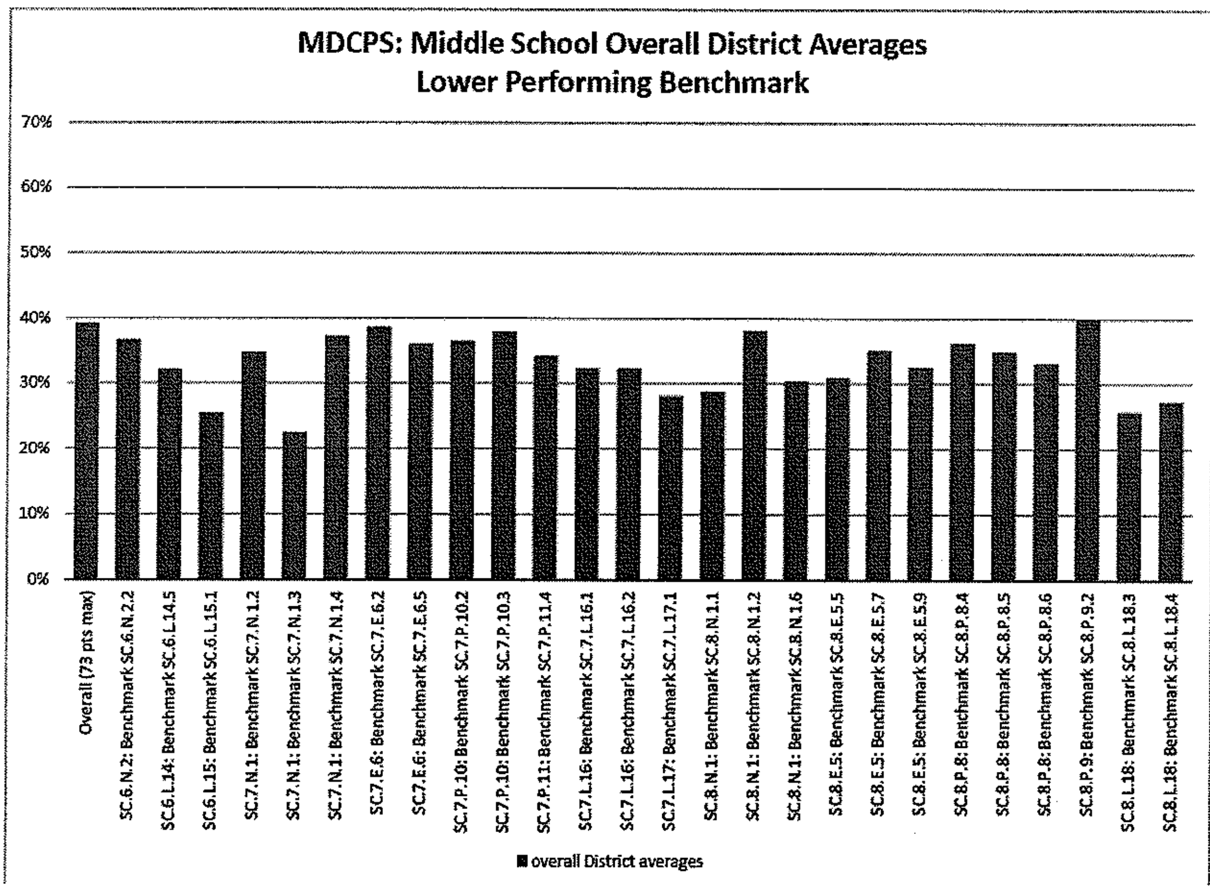
User Name: MDCPS Employee Number

Initial Password: MiamiDade2013 (case sensitive)

After the initial log in you will be prompted to change this password

Data Driven Instruction Discussion:


MDCPS: Middle School Overall District Averages
Higher Performing Benchmark
70%
60%
50%
40%
30%
20%
10%
0%
Overall (73 pts max)
SC.6.N.3: Benchmark SC.6.N.3.1
SC.6.E.6: Benchmark SC.6.E.6.1
SC.6.E.7: Benchmark SC.6.E.7.4
SC.6.E.7: Benchmark SC.6.E.7.5
SC.6.P.11: Benchmark SC.6.P.11.1
SC.6.P.13: Benchmark SC.6.P.13.1
SC.6.P.13: Benchmark SC.6.P.13.3
SC.6.L.14: Benchmark SC.6.L.14.1
SC.6.L.14: Benchmark SC.6.L.14.2
SC.6.L.14: Benchmark SC.6.L.14.4
SC.7.N.1: Benchmark SC.7.N.1.5
SC.7.N.2: Benchmark SC.7.N.2.1
SC.7.N.3: Benchmark SC.7.N.3.1
SC.7.N.3: Benchmark SC.7.N.3.2
SC.7.E.6: Benchmark SC.7.E.6.4
SC.7.P.10: Benchmark SC.7.P.10.1
SC.7.P.11: Benchmark SC.7.P.11.1
SC.7.P.11: Benchmark SC.7.P.11.2
SC.7.L.15: Benchmark SC.7.L.15.1
SC.7.L.15: Benchmark SC.7.L.15.2
SC.7.L.15: Benchmark SC.7.L.15.3
SC.7.L.17: Benchmark SC.7.L.17.2
SC.7.L.17: Benchmark SC.7.L.17.3
SC.8.E.5: Benchmark SC.8.E.5.1
SC.8.E.5: Benchmark SC.8.E.5.3
SC.8.E.5: Benchmark SC.8.E.5.10
SC.8.E.5: Benchmark SC.8.E.5.11
SC.8.P.8: Benchmark SC.8.P.8.3
overall District averages


MDCPS: Middle School Overall District Averages
Lower Performing Benchmark
70%
60%
50%
40%
30%
20%
10%
0%
Overall (73 pts max)
SC.6.N.2: Benchmark SC.6.N.2.2
SC.6.L.14: Benchmark SC.6.L.14.5
SC.6.L.15: Benchmark SC.6.L.15.1
SC.7.N.1: Benchmark SC.7.N.1.2
SC.7.N.1: Benchmark SC.7.N.1.3
SC.7.N.1: Benchmark SC.7.N.1.4
SC.7.E.6: Benchmark SC.7.E.6.2
SC.7.E.6: Benchmark SC.7.E.6.5
SC.7.P.10: Benchmark SC.7.P.10.2
SC.7.P.10: Benchmark SC.7.P.10.3
SC.7.P.11: Benchmark SC.7.P.11.4
SC.7.L.16: Benchmark SC.7.L.16.1
SC.7.L.16: Benchmark SC.7.L.16.2
SC.7.L.17: Benchmark SC.7.L.17.1
SC.8.N.1: Benchmark SC.8.N.1.1
SC.8.N.1: Benchmark SC.8.N.1.2
SC.8.N.1: Benchmark SC.8.N.1.6
SC.8.E.5: Benchmark SC.8.E.5.5
SC.8.E.5: Benchmark SC.8.E.5.7
SC.8.E.5: Benchmark SC.8.E.5.9
SC.8.P.8: Benchmark SC.8.P.8.4
SC.8.P.8: Benchmark SC.8.P.8.5
SC.8.P.8: Benchmark SC.8.P.8.6
SC.8.P.9: Benchmark SC.8.P.9.2
SC.8.L.18: Benchmark SC.8.L.18.3
SC.8.L.18: Benchmark SC.8.L.18.4
overall District averages

Competitions Updates

- The Department of Mathematics and Science is providing the following information on the Miami-Dade STEM Expo and its related competitions, the South Florida Regional Science and Engineering Fair, the SECME Olympiad & Festival, and the Elementary Science Fair:
- Registration and project check-in will take place according to the following schedule:
  - **Online registration** All projects intended to be submitted to all science competitions **must be registered** during the specified time-frame. (**See attached *Science Competitions Deadlines Checklist 2013-2014***)

Online Registration (Date range)	Event
November 4 - December 6, 2013	Elementary Science Fair.
November 8 - December 9, 2013	South Florida Regional Science and Engineering Fair
November 8 - December 9, 2013	SECME

  - Hard-copies of signed, required documentation for all projects must arrive at the Department of Science by the following dates no later than **4:00 p.m.** All paperwork should be hand delivered. Please **do not submit documentation via school mail or post office mail** since a delivery date to the Department of Mathematics and Science cannot be ensured.

Registration Documentation and Fees	Event
December 12, 2013	Elementary Science Fair.
December 12, 2013	South Florida Regional Science and Engineering Fair
December 12, 2013	SECME

- **Project /Entry fees**: (**See attached *Science Competitions Deadlines Checklist 2013-2014***)
  - Science Fair: **$20 per project board**, research paper, and/or bridge
  - SECME: **$50 per school level** (i.e. For combined grade level school, entry fee is per level: elementary, middle and/or senior high)
- Please note that projects with **incomplete registrations and/or missing required forms will not be considered for participation and will be disqualified**.
- **Project/Entry Check-in:**
  - Friday, **January 24th, 2014;** Time: **1:00 p.m. – 7:00 p.m.**
  - Location: **(see attached checklist for details)**
    - Miami Dade College, North Campus
      11380 Northwest 27 Avenue
      Miami, FL 33167
- **Competition Day:** Saturday, **January 25th, 2014,** Time: **8:30 a.m. – 5:00 p.m.**
  - Location: **(see attached checklist for details)**
    - Miami Dade College, North Campus
      11380 Northwest 27 Avenue
      Miami, FL 33167
- **Students are expected to remain for the entire day's schedule, until judging is completed.**
- A detailed competition program will be sent to registered schools in December.
- Electronic registration is **required** for participation of each project (South Florida Regional Science and Engineering Fair, SECME Olympiad & Festival, and Elementary Science Fair) and will be available under the following links:
  - Elementary Science Fair: http://science.dadeschools.net/ElementaryScienceFair/default.html
  - South Florida Regional Science and Engineering Fair: http://science.dadeschools.net/scienceFairEntryForm.asp
  - SECME: http://science.dadeschools.net/SECMEcompetitionForm.asp
- **It is extremely important that the contact teacher for the specific competition, project sponsor, or project designated supervisor review the online registration for completion so it matches the paperwork that will be submitted.**
- Students and contact teacher must keep a copy of the online submission.
- Please see attached ***Science Competitions Deadlines Checklist 2013-2014*** for details on specific competitions and deadlines.
- Board Item H-11 proffered by Dr. Martin Karp, Member, and approved by The School Board on January 16, 2008, indicates that all middle and senior high schools are required to submit at least one (1) entry in the South Florida Regional Science and Engineering Fair (SFRSEF).

Common Core standards in Science: Speaking in Listening

College and Career Readiness Anchor Standards for Speaking and Listening

The grades 6–12 standards on the following pages define what students should understand and be able to do by the end of each grade. They correspond to the College and Career Readiness (CCR) anchor standards below by number. The CCR and grade-specific standards are necessary complements—the former providing broad standards, the latter providing additional specificity—that together define the skills and understandings that all students must demonstrate.

Comprehension and Collaboration

1. Prepare for and participate effectively in a range of conversations and collaborations with diverse partners, building on others' ideas and expressing their own clearly and persuasively.
2. Integrate and evaluate information presented in diverse media and formats, including visually, quantitatively, and orally.
3. Evaluate a speaker's point of view, reasoning, and use of evidence and rhetoric.

Presentation of Knowledge and Ideas

4. Present information, findings, and supporting evidence such that listeners can follow the line of reasoning and the organization, development, and style are appropriate to task, purpose, and audience.
5. Make strategic use of digital media and visual displays of data to express information and enhance understanding of presentations.
6. Adapt speech to a variety of contexts and communicative tasks, demonstrating command of formal English when indicated or appropriate.

Note on range and content of student speaking and listening

To become college and career ready, students must have ample opportunities to take part in a variety of rich, structured conversations—as part of a whole class, in small groups, and with a partner—built around important content in various domains. They must be able to contribute appropriately to these conversations, to make comparisons and contrasts, and to analyze and synthesize a multitude of ideas in accordance with the standards of evidence appropriate to a particular discipline. Whatever their intended major or profession, high school graduates will depend heavily on their ability to listen attentively to others so that they are able to build on others' meritorious ideas while expressing their own clearly and persuasively.

New technologies have broadened and expanded the role that speaking and listening play in acquiring and sharing knowledge and have tightened their link to other forms of communication. The Internet has accelerated the speed at which connections between speaking, listening, reading, and writing can be made, requiring that students be ready to use these modalities nearly simultaneously. Technology itself is changing quickly, creating a new urgency for students to be adaptable in response to change.

Speaking and Listening Standards 6–12

SL

The following standards for grades 6–12 offer a focus for instruction in each year to help ensure that students gain adequate mastery of a range of skills and applications. *Students advancing through the grades are expected to meet each year's grade-specific standards and retain or further develop skills and understandings mastered in preceding grades.*

Grade 6 students:	Grade 7 students:	Grade 8 students:
Comprehension and Collaboration		
1. Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on *grade 6 topics, texts, and issues*, building on others' ideas and expressing their own clearly. a. Come to discussions prepared, having read or studied required material; explicitly draw on that preparation by referring to evidence on the topic, text, or issue to probe and reflect on ideas under discussion. b. Follow rules for collegial discussions, set specific goals and deadlines, and define individual roles as needed. c. Pose and respond to specific questions with elaboration and detail by making comments that contribute to the topic, text, or issue under discussion. d. Review the key ideas expressed and demonstrate understanding of multiple perspectives through reflection and paraphrasing.	1. Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on *grade 7 topics, texts, and issues*, building on others' ideas and expressing their own clearly. a. Come to discussions prepared, having read or researched material under study; explicitly draw on that preparation by referring to evidence on the topic, text, or issue to probe and reflect on ideas under discussion. b. Follow rules for collegial discussions, track progress toward specific goals and deadlines, and define individual roles as needed. c. Pose questions that elicit elaboration and respond to others' questions and comments with relevant observations and ideas that bring the discussion back on topic as needed. d. Acknowledge new information expressed by others and, when warranted, modify their own views.	1. Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on *grade 8 topics, texts, and issues*, building on others' ideas and expressing their own clearly. a. Come to discussions prepared, having read or researched material under study; explicitly draw on that preparation by referring to evidence on the topic, text, or issue to probe and reflect on ideas under discussion. b. Follow rules for collegial discussions and decision-making, track progress toward specific goals and deadlines, and define individual roles as needed. c. Pose questions that connect the ideas of several speakers and respond to others' questions and comments with relevant evidence, observations, and ideas. d. Acknowledge new information expressed by others, and, when warranted, qualify or justify their own views in light of the evidence presented.
2. Interpret information presented in diverse media and formats (e.g., visually, quantitatively, orally) and explain how it contributes to a topic, text, or issue under study.	2. Analyze the main ideas and supporting details presented in diverse media and formats (e.g., visually, quantitatively, orally) and explain how the ideas clarify a topic, text, or issue under study.	2. Analyze the purpose of information presented in diverse media and formats (e.g., visually, quantitatively, orally) and evaluate the motives (e.g., social, commercial, political) behind its presentation.
3. Delineate a speaker's argument and specific claims, distinguishing claims that are supported by reasons and evidence from claims that are not.	3. Delineate a speaker's argument and specific claims, evaluating the soundness of the reasoning and the relevance and sufficiency of the evidence.	3. Delineate a speaker's argument and specific claims, evaluating the soundness of the reasoning and relevance and sufficiency of the evidence and identifying when irrelevant evidence is introduced.
Presentation of Knowledge and Ideas		
4. Present claims and findings, sequencing ideas logically and using pertinent descriptions, facts, and details to accentuate main ideas or themes; use appropriate eye contact, adequate volume, and clear pronunciation.	4. Present claims and findings, emphasizing salient points in a focused, coherent manner with pertinent descriptions, facts, details, and examples; use appropriate eye contact, adequate volume, and clear pronunciation.	4. Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation.
5. Include multimedia components (e.g., graphics, images, music, sound) and visual displays in presentations to clarify information.	5. Include multimedia components and visual displays in presentations to clarify claims and findings and emphasize salient points.	5. Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest.
6. Adapt speech to a variety of contexts and tasks, demonstrating command of formal English when indicated or appropriate. (See grade 6 Language standards 1 and 3 on page 53 for specific expectations.)	6. Adapt speech to a variety of contexts and tasks, demonstrating command of formal English when indicated or appropriate. (See grade 7 Language standards 1 and 3 on page 53 for specific expectations.)	6. Adapt speech to a variety of contexts and tasks, demonstrating command of formal English when indicated or appropriate. (See grade 8 Language standards 1 and 3 on page 53 for specific expectations.)

Speaking and Listening Standards 6–12

SL

The CCR anchor standards and high school grade-specific standards work in tandem to define college and career readiness expectations—the former providing broad standards, the latter providing additional specificity.

Grades 9–10 students:	Grades 11–12 students:
Comprehension and Collaboration	
1. Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on *grades 9–10 topics, texts, and issues*, building on others' ideas and expressing their own clearly and persuasively. a. Come to discussions prepared, having read and researched material under study; explicitly draw on that preparation by referring to evidence from texts and other research on the topic or issue to stimulate a thoughtful, well-reasoned exchange of ideas. b. Work with peers to set rules for collegial discussions and decision-making (e.g., informal consensus, taking votes on key issues, presentation of alternate views), clear goals and deadlines, and individual roles as needed. c. Propel conversations by posing and responding to questions that relate the current discussion to broader themes or larger ideas; actively incorporate others into the discussion; and clarify, verify, or challenge ideas and conclusions. d. Respond thoughtfully to diverse perspectives, summarize points of agreement and disagreement, and, when warranted, qualify or justify their own views and understanding and make new connections in light of the evidence and reasoning presented.	1. Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on *grades 11–12 topics, texts, and issues*, building on others' ideas and expressing their own clearly and persuasively. a. Come to discussions prepared, having read and researched material under study; explicitly draw on that preparation by referring to evidence from texts and other research on the topic or issue to stimulate a thoughtful, well-reasoned exchange of ideas. b. Work with peers to promote civil, democratic discussions and decision-making, set clear goals and deadlines, and establish individual roles as needed. c. Propel conversations by posing and responding to questions that probe reasoning and evidence; ensure a hearing for a full range of positions on a topic or issue; clarify, verify, or challenge ideas and conclusions; and promote divergent and creative perspectives. d. Respond thoughtfully to diverse perspectives; synthesize comments, claims, and evidence made on all sides of an issue; resolve contradictions when possible; and determine what additional information or research is required to deepen the investigation or complete the task.
2. Integrate multiple sources of information presented in diverse media or formats (e.g., visually, quantitatively, orally) evaluating the credibility and accuracy of each source.	2. Integrate multiple sources of information presented in diverse formats and media (e.g., visually, quantitatively, orally) in order to make informed decisions and solve problems, evaluating the credibility and accuracy of each source and noting any discrepancies among the data.
3. Evaluate a speaker's point of view, reasoning, and use of evidence and rhetoric, identifying any fallacious reasoning or exaggerated or distorted evidence.	3. Evaluate a speaker's point of view, reasoning, and use of evidence and rhetoric, assessing the stance, premises, links among ideas, word choice, points of emphasis, and tone used.
Presentation of Knowledge and Ideas	
4. Present information, findings, and supporting evidence clearly, concisely, and logically such that listeners can follow the line of reasoning and the organization, development, substance, and style are appropriate to purpose, audience, and task.	4. Present information, findings, and supporting evidence, conveying a clear and distinct perspective, such that listeners can follow the line of reasoning, alternative or opposing perspectives are addressed, and the organization, development, substance, and style are appropriate to purpose, audience, and a range of formal and informal tasks.
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.	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.
6. Adapt speech to a variety of contexts and tasks, demonstrating command of formal English when indicated or appropriate. (See grades 9–10 Language standards 1 and 3 on page 54 for specific expectations.)	6. Adapt speech to a variety of contexts and tasks, demonstrating a command of formal English when indicated or appropriate. (See grades 11–12 Language standards 1 and 3 on page 54 for specific expectations.)

Argumentation Reflections

Reflect on these questions:

1. Key vocabulary
2. How can I apply them to current and future standards?
3. What type of training or support do I need for this?

ARGUMENTATION IN SCIENCE EDUCATION

HELPING STUDENTS UNDERSTAND THE NATURE OF SCIENTIFIC ARGUMENTATION SO THEY CAN MEET THE NEW SCIENCE STANDARDS

Victor Sampson, Patrick Enderle, and Jonathon Grooms

A *Framework for K–12 Science Education* (NRC 2012) and subsequent *Next Generation Science Standards* (Achieve Inc. 2013) will substantially influence the teaching and learning of science in the United States. The *Framework*, for example, calls for students to learn about several practices related to scientific argumentation. These practices—arguing from evidence (practice #6) and obtaining, evaluating, and communicating information (practice #8)—are embedded throughout the *Next Generation Science Standards* (NGSS). Many teachers, as a result, need to re-focus their curriculum and methods to teach these practices. This article will help teachers understand the nature of scientific argumentation so they can help students reach the new benchmarks. It will also explain challenges students face when they participate in scientific argumentation and will list resources teachers can use to help students learn from and about scientific argumentation in the classroom.

What counts as an argument in science?

In scientific argumentation, individuals attempt to support, challenge, or refine a claim on the basis of evidence (Norris, Philips, and Osborne 2007). Claims include conjectures, conclusions, explanations, models, or an answer to a research question. Scientists often rely on evidence to support their claims. To generate a compelling argument, however, scientists must also convince others that their evidence is relevant and of high quality. Scientists, as a result, spend a great deal of time assessing, critiquing, and defending the evidence used to support or challenge claims when they engage in scientific argumentation.

Students must also learn how to construct an evidence-based argument and evaluate the evidence presented by others. We developed an argument framework (Figure 2, p. 32) to help students understand what counts as evidence in science and how to construct and evaluate a scientific argument. In this framework, an argument consists of a claim, evidence, and a justification of the evidence.

The claim, as described earlier, is a conjecture, conclusion, explanation, principle, or some other answer to a research question. Evidence is data or findings from studies. Note that in this framework, data and evidence have different meanings. Scientists collect data or gather findings from other studies then transform the data or findings into evidence. To do this, they must first analyze the data or findings (e.g., by making comparisons between groups, looking for trends over time, identifying relationships between variables, or synthesizing available literature), and then they provide an interpretation of their analysis. Finally, in this framework, they justify the evidence, explaining its importance by making the specific principle, concept, or underlying assumption that guided the analysis of the data (or findings) and the interpretation of their analysis explicit.

To clarify, let's examine the argument made by James Watson and Francis Crick in one of the most important scientific papers in history. In their groundbreaking article, "A structure for Deoxyribose Nucleic Acid" (1953), they set out to describe a "radically different structure" (p. 737) for the DNA molecule. Their claim was complex, describing not only the helical chains of DNA and the directions they run in relation to each other but also how the purine and pyrimidine bases hold the two chains together:

> ...only specific pairs of bases can bond together. These pairs are: adenine (purine) with thymine (pyrimidine), and guanine (purine) with cytosine (pyrimidine). In other words, if an adenine forms one member of a pair, on either chain, then on these assumptions the other member must be thymine; similarly for guanine and cytosine. (p. 737)

Watson and Crick then provided evidence based on the findings of other scientists:

> It has been found experimentally [citations] that the ratio of the amounts of adenine to thymine, and the ratio of guanine to cytosine, are always very close to unity for deoxyribose nucleic acid. (p. 737)

This evidence reflected their analysis of findings from two different studies (one by Chargaff and one by Wyatt) and their interpretation of their analysis of the available literature. Watson and Crick then provided a justification of most, but not all, of the evidence they decided to include in their argument:

> The previously published x-ray data on deoxyribose nucleic acid are insufficient for a rigorous test of our structure. So far as we can tell, it is roughly compatible with the experimental data, but it must be regarded as unproved until it has been checked against more exact results. Some of these are given in the following communications. We were not aware of the details of the results presented there when we devised our structure, which rests mainly though not entirely on published experimental data and stereochemical arguments. (p. 737)

As part of their justification of their evidence, Watson and Crick explained some of the assumptions underlying their analysis and interpretations. They also explained why they didn't use some other findings (x-ray data) in their argument. Note, however, that this article was short (less than 900 words) and omitted some of the assumptions underlying their analysis and interpretations. Accordingly, Watson and Crick included this caveat at the end of their article:

FIGURE 1

The effect of weights on pendulum speed.

# of weights	# of swings (in 10 seconds)
None	0
2	3
4	6
5	6
6	7
7	7
8	6

Student claim: The optimal number of weights was 6 or 7 because with 8 weights, the pendulum's speed slowed by about 1 swing per section. This proves that the pendulums swing faster depending on the amount of weight.

Full details of the structure, including the conditions assumed in building it, together with a set of coordinates for the atoms, will be published elsewhere. (p. 737)

As this example illustrates, scientists must argue from evidence to support their claims. They must make clear the assumptions underlying their analysis of data and their interpretations of the analysis to convince others that the evidence they used was relevant and valid. The framework in Figure 2 offers students guidance about what to include in a scientific argument.

Students also need to learn the criteria (Figure 2) that scientists use to evaluate and critique the arguments developed by other scientists. We describe these criteria as either empirical or theoretical. Empirical criteria are used to evaluate how data was collected and analyzed and how well the claims fit the evidence. Theoretical criteria, in contrast, address how consistent the claim is with accepted scientific knowledge and the appropriateness of the theoretical framework that was used to guide the interpretation of the results.

What counts as quality in these two categories of criteria can vary from discipline to discipline (e.g., physics, biology, chemistry) and across fields within a discipline (e.g., cell biology, evolutionary biology, biochemistry). These differences arise because scientists in different disciplines and fields investigate different types of phenomena, use different modes of inquiry (e.g., experimentation vs. fieldwork), and rely on different theories to guide their analysis and interpretation of data. Students need to understand that the empirical and theoretical criteria that scientists use to evaluate arguments are shaped by the theories, modes of inquiry, and ways of communicating that are valued within a discipline or field.

Challenges students face in scientific argumentation

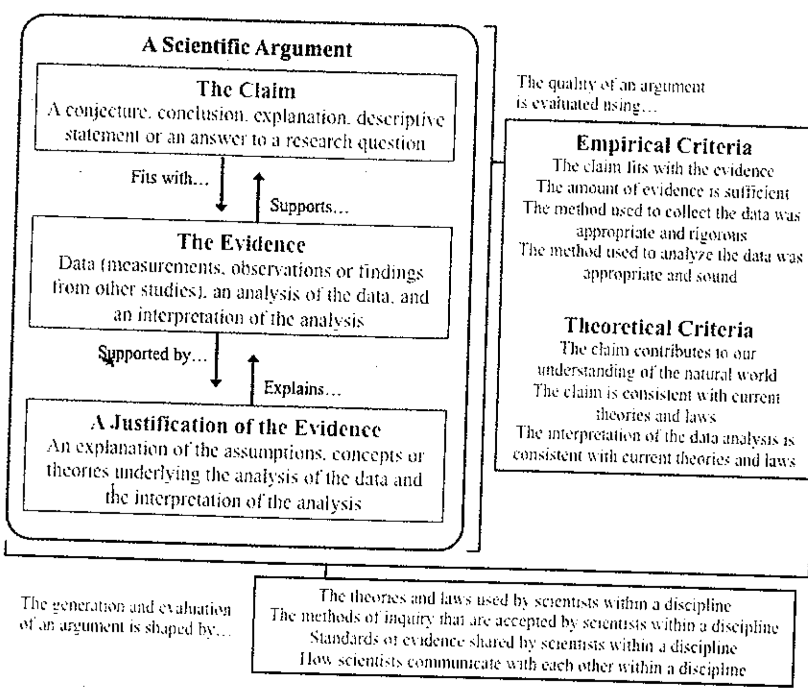
Students often encounter challenges when asked to craft an evidence-based argument in scienc (NRC 2012). Many students don't understand the differ ence between data and evidence so only include data ir their argument. Other students struggle with transform ing data into evidence and therefore inappropriately ana lyze their data or misinterpret the results of their analysis. Some students have a confirmation bias and only seek out data (or findings) that support their ideas and ignore the rest. Others make hasty generalizations based on limited information.

The biggest challenge for students, however, is justifying their evidence. Most students don't understand the value of making their assumptions explicit to others, or they fail to discuss the theory, law, or concept that guided their analysis of the data they collected and the interpretation of their analysis. Many students, as a consequence, provide an interpretation of their results to justify their evidence or they just declare that their evidence proves their claim.

To illustrate some of these challenges, we offer a sample argument typical of students who haven't yet learned about scientific arguments in school. At the start of the school year, students were directed to develop an argument consisting of a claim, evidence, and justification of the

FIGURE 2

A framework that illustrates the components of an empirical scientific argument and some criteria that can be used to evaluate them.



evidence to answer the question: "Why do some pendulums swing faster than others?"

After designing and carrying out an investigation to gather data (Figure 1, p. 31), the group produced the following argument: "Some pendulums swing faster depending on the amount of weight because of the balance between the inertia of the pendulum and the gravity acting upon it."

These students did not meaningfully analyze their data or interpret their analysis. They also showed a confirmation bias, collecting data about only one factor (the mass of the bob) and making an inaccurate generalization based on their limited information. They failed to justify the "evidence" they used to support their claim, simply declaring that their data proves their claim. Teachers need to be mindful of these pitfalls when students try to argue from evidence.

Students also struggle when asked to evaluate the conclusions of others in the science classroom (NRC 2012). Many, for cultural or other reasons, consider it disrespectful to question the ideas of their classmates, or they are inhibited by existing relationships with their peers. Other students see little value in discussing the merits of an idea, preferring to wait for the teacher or friends to reveal the right answer. When students do engage in argumentation with their classmates, they often don't argue from evidence but use personal attacks, an appeal to authority figures, or personal experiences or beliefs to support or challenge an idea. Most students, then, need more opportunities to learn how to participate in argumentation consistent with the norms and values of the scientific community.

Conclusion

The focus of the science curriculum needs to change so students can learn how to participate in the practices of science. Teachers must emphasize "how we know" as much as "what we know" (i.e., the scientific concepts outlined in most state standards). Teachers need to provide students more opportunities to craft scientific arguments and participate in discussions that require them to support and challenge claims based on evidence. Teachers need to help students learn how to use the same criteria that scientists use to evaluate an argument. Finally, teachers need to give students a reason to discuss alternative claims, the available evidence, and their underlying assumptions during a lesson. These tasks can be difficult, but help is available (see "Resources").

We hope this article will spark discussions about the varied ways to help students learn how to argue from evidence and evaluate information in the context of science. These types of practices are key features of the *Framework* and the *NGSS*. It's time for all of us to focus our efforts on helping students learn about these new practices. ■

Victor Sampson (victor.sampson@gmail.com) *is an assistant professor of science education; Patrick Enderle* (patrick.enderleadi@gmail.com) *and Jonathon Grooms* (grooms.fsu@gmail.com) *are assistants in research, all at Florida State University in Tallahassee.*

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Resources

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Sampson, V., and S. Schleigh. 2012. *Scientific argumentation in biology: 30 classroom activities.* Arlington, VA: NSTA Press. The activities in this book align with the *Framework* and include assessments, rubrics, examples of student arguments, and teacher notes.

Web-based Inquiry Science Environment (WISE): *http://wise.berkeley.edu.* This free learning environment includes projects related to arguing from evidence. Includes project overviews and information on how the project aligns with content standards.

Differentiated Instruction reflections and ideas:

Creative

- Create a comic strip or story of DNA characters and how they "replicated" one day.
- Include the effects of a "mutation" they caused in themselves.
- Underline important vocabulary.

Practical

- Make a set of instructions in logical order of how a DNA strand becomes two strands in the nucleus.
- Include a description of what happens when there is a mutation.
- Underline important vocabulary.

Analytical

- Create a concept map with drawings and descriptions of all the stages of the DNA replication process.
- Include a branch that describes what occurs from mutation.
- Underline important vocabulary.

Creative	
Practical	
Analytical	

BENCHMARK SC.7.P.11.2

Reporting Category	Physical Science
Standard	**Big Idea 11** Energy Transfer and Transformations
Benchmark	**SC.7.P.11.2 Investigate and describe the transformation of energy from one form to another. (Also assesses SC.6.P.11.1 and SC.7.P.11.3.)**
Also Assesses	**SC.6.P.11.1** Explore the Law of Conservation of Energy by differentiating between potential and kinetic energy. Identify situations where kinetic energy is transformed into potential energy and vice versa.
	SC.7.P.11.3 Cite evidence to explain that energy cannot be created nor destroyed, only changed from one form to another.
Benchmark Clarifications	Students will identify and/or describe the transformation of energy from one form to another.
	Students will differentiate between potential energy and kinetic energy.
	Students will identify and/or explain situations where energy is transformed between kinetic energy and potential energy.
	Students will identify and/or describe examples of the law of conservation of energy.
Content Limits	Items will not assess transformations involving nuclear energy.
	Items may address a maximum of five energy transformations.
	Items will not require calculations.
	Items assessing energy transformations will not be placed in a Life Science context.
Stimulus Attributes	None specified
Response Attributes	None specified
Prior Knowledge	Items may require the student to apply science knowledge described in the NGSSS from lower grades. This benchmark requires prerequisite knowledge from SC.3.P.11.2 and SC.5.P.10.4.

BENCHMARK SC.7.E.6.4

Reporting Category	Earth and Space Science
Standard	**Big Idea 6** Earth Structures
Benchmark	SC.7.E.6.4 **Explain and give examples of how physical evidence supports scientific theories that Earth has evolved over geologic time due to natural processes. (Also assesses SC.7.E.6.3.)**
Also Assesses	SC.7.E.6.3 Identify current methods for measuring the age of Earth and its parts, including the law of superposition and radioactive dating.
Benchmark Clarifications	Students will identify examples of and/or explain physical evidence that supports scientific theories that Earth has evolved over geologic time due to natural processes. Students will identify and/or describe current scientific methods for measuring the age of Earth and its parts.
Content Limits	Items may address fossil records but should not require knowledge or recognition of specific organisms. Items may address folding and faulting as related to the law of superposition. Items assessing radioactive dating will be limited to a conceptual level. Items will not require calculations or address half-life. Items addressing geologic time will not require specific knowledge of eras, periods, or epochs.
Stimulus Attributes	None specified
Response Attributes	None specified
Prior Knowledge	This benchmark grouping is foundational. These concepts have not been introduced in the NGSSS prior to this grade-level grouping.

Benchmark SC.8.E.5.5

Reporting Category	Earth and Space Science
Standard	**Big Idea 5** Earth in Space and Time
Benchmark	**SC.8.E.5.5 Describe and classify specific physical properties of stars: apparent magnitude (brightness), temperature (color), size, and luminosity (absolute brightness). (Also assesses SC.8.E.5.6.)**
Also Assesses	**SC.8.E.5.6** Create models of solar properties, including rotation, structure of the Sun, convection, sunspots, solar flares, and prominences.
Benchmark Clarifications	Students will describe and/or classify physical properties of stars: apparent magnitude, temperature (color), size, and absolute brightness. Students will evaluate models of solar properties and/or explain solar characteristics, including rotation, structure of the Sun, convection, sunspots, solar flares, and prominences.
Content Limits	Items addressing stars will focus on main sequence stars and their properties. Items will not assess stages of stellar evolution. Items will not assess the specific chemical composition of stars.
Stimulus Attributes	Distances will be given in units of astronomical units (AU) or light-years. The phrase *absolute brightness* should be used rather than *luminosity*.
Response Attribute	Distances will be given in units of astronomical units (AU) or light-years.
Prior Knowledge	Items may require the student to apply science knowledge described in the NGSSS from lower grades. This benchmark requires prerequisite knowledge from SC.3.E.5.1, SC.3.E.5.2, SC.3.E.5.3, and SC.5.E.5.1.

Turn in Reflection feedback before you leave

Final Reflections
Middle School Science

Please leave your reflections on the table

- 3 Things I Observed
    -
    -
    -
- 2 Things I Learned
    -
    -
- 1 Thing That I will do differently
    -
- Question(s) I still have

Your feedback is very important to us. Please take a minute to complete this form.

1. On a scale from 1 to 4, how would you rate this workshop? (4=highest 1=lowest) _______
2. Identify any area(s) for improvement
3. Identify one thing that must be kept
4. Additional comments

The Action Plan you fill out, scan, and upload to EdModo with evidence of implementation

Department of Mathematics and Science
Science Department Chair/Coach

FOLLOW-UP: ACTION PLAN
Required for Master Plan Points

To be received no later than **Friday, November 22, 2013**

Electronically: Please be advised that sign-in sheets/teacher reflections will have to *be* scanned

To: Edmodo Group **9hab2h**
Subject: Follow-up *Science Leaders Discourse*____ ***(indicate session attended)***

Action	Person Responsible	Date Completed
Meet with principal to share the content of this professional development and collaborate to present to targeted staff.		
Conduct in-depth planning sessions with grade appropriate science teachers focusing on *Science Leaders Discourse* for targeted grade level. to include but not limited to: • Learning goal use • Common core: Argumentation For these planning sessions, attach: ☑ Agenda with date(s) ☑ Sign-in sheets of planning sessions ☑ **Student work samples showing the use of a learning goal***********		

Participant Instructor: ______________________ **Work Location #:**_______________

School: __________________________________ **Region:** ________________

Principal's Signature: ____

Comments: