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# Moving Toward More Equitable Science Assessments for English Learners

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**TERC**

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# How is research on science assessments relevant to you?

We believe it is relevant to developing:

- Assessments of all kinds
- Curriculum
- Professional development

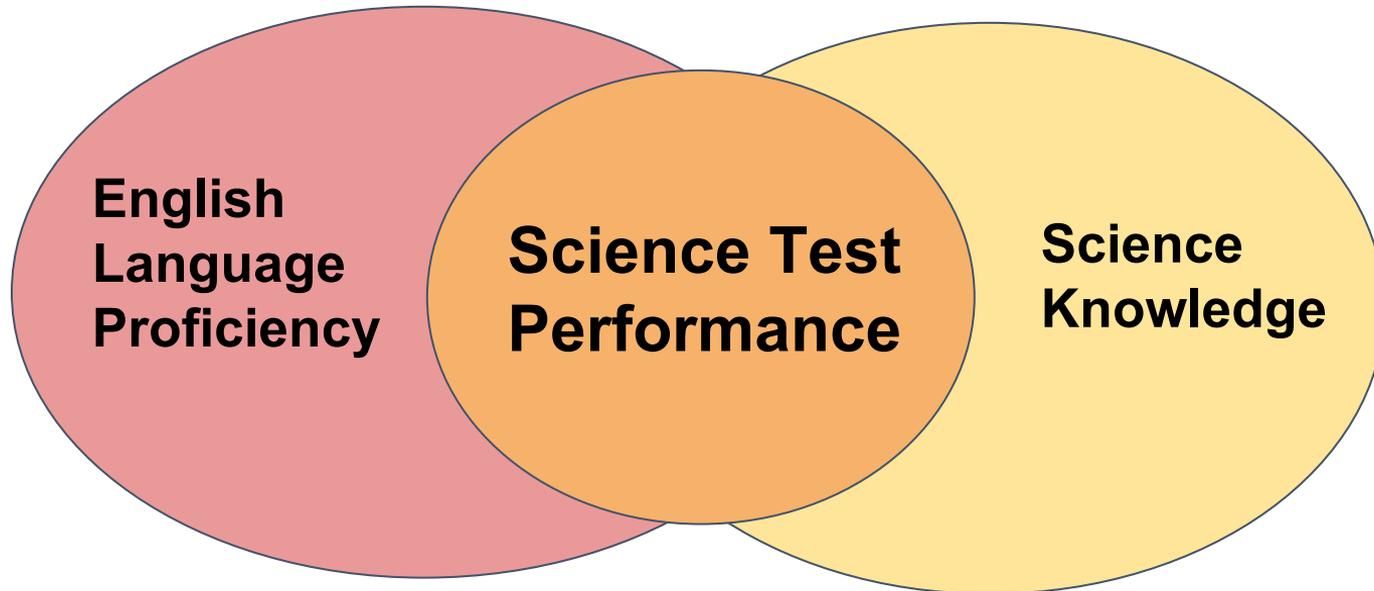
# How could this presentation help you?

- Offers ways to make more equitable science assessments for ELs
- Offers an expanded perspective on all materials you create for students, teachers, and parents

# Overview

- 10 min → 1) Description of our research work
- 30 min → 2) 5 Main findings
  - a) Includes break for Clarifying Questions
- 5 min → 3) 5 Main takeaways
- 15 min → 4) Q & A

# Assessing what English Learners (ELs) know and can do in science *in English* is difficult.



# We investigated how the language of science test items affects ELs' ability to show what they know on science tests

- Partnered with the MA Department of Elementary and Secondary Education (MA DESE)
- Focused on the Grade 5 Massachusetts Comprehensive Assessment System Science and Technology/Engineering (MCAS STE) test

# What did we do?

- 9 years of research
- 2 projects

The research reported here was supported by the Institute of Education Sciences, U.S. Department of Education through Grant R305A110122 and Grant R305A150218. The opinions expressed herein are those of the authors and do not reflect the opinions of the funding agency.



- **1 project focused on Multiple-Choice Items**

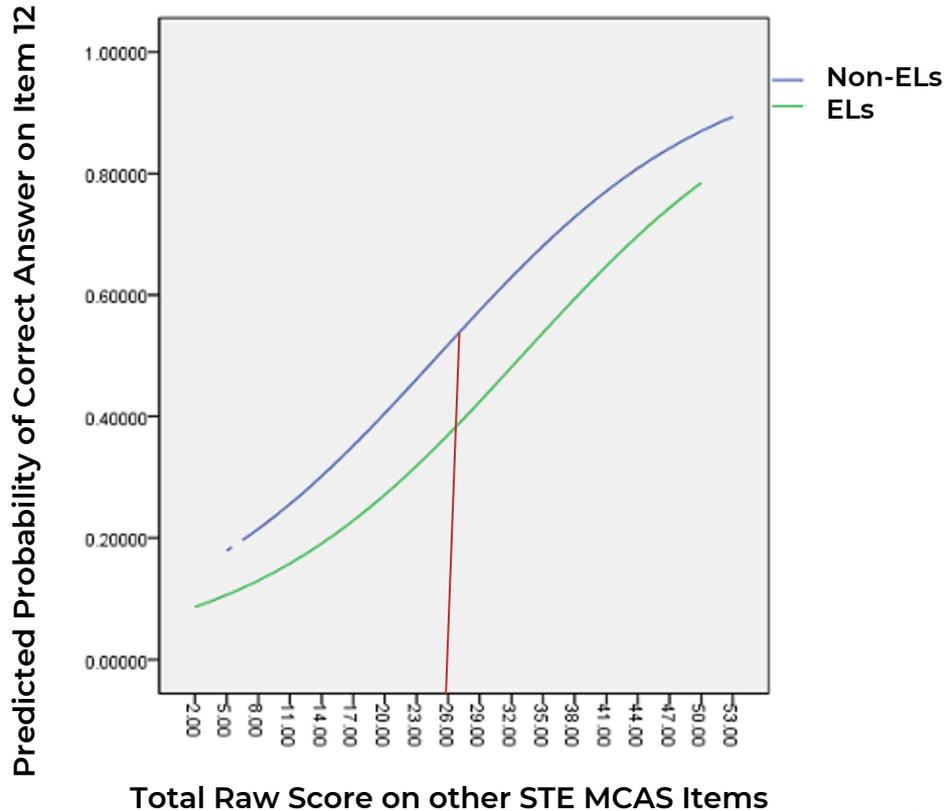
- Correlation study
- Interviews with Grade 5 students about MC items
- Linguistic Simplification study

- **1 project focused on Constructed-Response Items**

- Analysis of who skipped CR items
- Interviews with Grade 5 students about CR items
- Multiple Regression Analyses

# Differential Item Functioning (DIF)

- DIF measures whether ELs and non-ELs who score the **same** on the other items of the test score **differently** on a particular test item.
- DIF is one indicator of possible test item bias.



# 5 Main Findings

# 1. Words Matter

# Which words help ELs?

## Technical words

- Words and terms with meanings specific to a science discipline
- Examples: *ecosystem, gravity, jet stream, evaporating*

# Why do we think Technical Words Can Help ELs?

**Because they are often taught explicitly in science class, so ELs and non-ELs both have opportunities to learn them.**

# Which Words Interfere?

## Unfamiliar, Non-Technical Words

- Unfamiliar words that do **not** have technical meanings
- Examples: *hose, repeatedly, unusually, specific, burrow*
- First defined using word frequency tables
- Better results when teachers coded items for words unfamiliar to Grade 5 ELs

# Example

## Unfamiliar Non-Technical words one teacher coded

0502. A cook notices a teakettle full of water on a stove. There is a cold window close to the spout of the kettle. The water begins to boil and water droplets begin to form on the window.

- a. Describe in detail what is happening to the water inside the kettle.
- b. Why do the water droplets form on the window? Be sure to explain in detail.

**Pink** - 50% or more of Grade 5 ELs unfamiliar with word

**Yellow** - 20-50% of Grade 5 ELs unfamiliar with word

(MA DOE, 2005)

**cook, teakettle, spout, kettle, describe**

# Student definitions for Unfamiliar Non-Technical words

**Teakettle:** *“I think a little like, a big like um, a big example of like, a cup?” \_Noemi*

**Spout:** *“It means to grow like in growing places...like a tree is growing a spout” \_ Ester*

# Why do we think Unfamiliar Non-Technical Words are sources of difficulty for ELs?

**Many Unfamiliar Non-Technical words are learned at home, not in school, therefore ELs may not know these words in English.**

## **2. How words are put together matters**

# Which word patterns matter?

Two patterns in Multiple-Choice items that interfere with the performance of ELs:

- Forced Comparison
- Reference Back

# Forced Comparison

- Appears frequently in Multiple-Choice items
- Occurs in items asking for an extreme case: the **best, most likely, greatest**, etc.
- “*Forces*” students to *compare* all answer choices to select the one that fulfills the extreme case.

# Example Item (Earthworm) with Forced Comparison

An earthworm was placed on top of a thick layer of moist topsoil in a pan. The pan was placed in a room with the lights on. **How did the earthworm most likely respond** to these conditions?

- A. by burrowing under the soil \*
- B. by crawling around in the pan
- C. by staying where it was placed
- D. by trying to crawl out of the pan

# Reference Back

The question sentence **refers back** to information that appeared earlier in the item that is **needed** to understand & answer the item.

# Same Item also contains Reference Back

An earthworm was placed on top of a thick layer of moist topsoil in a pan. The pan was placed in a room with **the lights on**. How did the earthworm most likely respond to **these conditions**?

- A. by burrowing under the soil\*
- B. by crawling around in the pan
- C. by staying where it was placed
- D. by trying to crawl out of the pan

\* Correct answer (MA DOE, 2004)

# Why are Forced Comparison and Reference Back sources of difficulty for ELs?

- Reader must construct meaning relationships across sentences.
- Reader must make inferences based on those relationships.
- For Forced Comparison, the reader needs to know ALL the words in the answer choices to make the best choice.

# **An Example From Our Interview Study**

## **Yolanda and the Earthworm**

An earthworm was placed on top of a thick layer of moist topsoil in a pan. The pan was placed in a room with the lights on. How did the earthworm **most likely** respond to **these conditions**?

- A. by burrowing under the soil\*
- B. by crawling around in the pan
- C. by staying where it was placed\*\*
- D. by trying to crawl out of the pan

\* Correct answer

\*\* Yolanda's answer

An earthworm was placed on top of a thick layer of moist topsoil in a pan. The pan was placed in a room with the lights on. How did the earthworm **most likely respond** to these conditions?

*I:* So this one says like “most likely respond”, do you know what that means, “most likely respond”?

*Y:* Most like, like much better, like something to say, something much better, something to speak about. Like if you were to say, like which one’s much better, but you have to say it mostly, like respond to an answer.

An earthworm was placed on top of a thick layer of moist topsoil in a pan. The pan was placed in a room with the lights on. How did the earthworm most likely respond to **these conditions**?

- A. by burrowing under the soil
- B. by crawling around in the pan
- C. by staying where it was placed
- D. by trying to crawl out of the pan

I: Okay. And what about “these conditions”, do you know what it’s talking about when it says “these conditions”?

Y: It’s like the answers underneath, like which one’s much better. Which one’s much better of these answers.

# The interview continued:

**I:** So if I said it in a little bit different way, like you have an earthworm and you put it on some dirt in a pan. And then you shine light on the pan, what will the earthworm do?

**Y:** It would move, it would just like go underneath, under the soil.

**I:** It would go under the soil? Why would it go under the soil?

**Y:** Because the last time, like I think I saw it on TV that earthworms don't really like the sun.

# Clarifying Questions?

# **3. Visuals Can Help**

# Example Items with Visuals

35) The picture below shows a compass

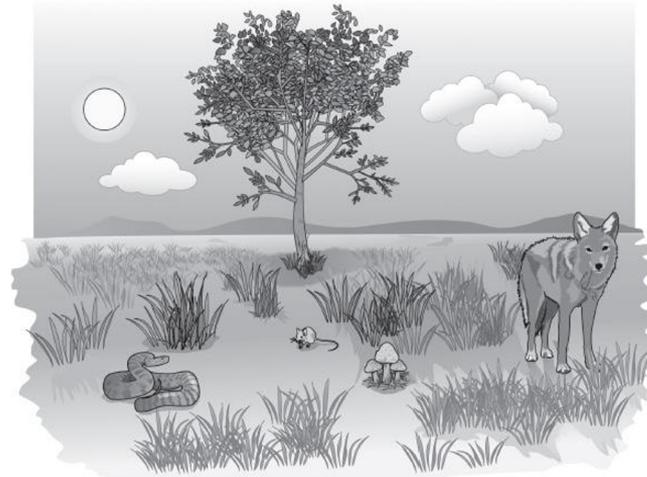


Which type of energy causes the needle on this compass to move?

- A. heat
- B. light
- C. magnetic
- D. sound

(MA DOE, 2005)

- 10 A prairie ecosystem includes many different organisms, such as grasses, coyotes, trees, mushrooms, snakes, and mice, as shown in the picture below. The energy needed by all the organisms in the ecosystem comes from one primary source.



- a. Identify the primary source of energy in the prairie ecosystem.
- b. Identify one producer, one consumer, and one decomposer shown in the picture of the prairie ecosystem.
- c. Explain how the energy from the primary source you identified in part (a) moves through the prairie ecosystem. Be sure to include producers, consumers, and decomposers in your answer.

(MA DESE, 2013)

# Which visuals can help in Multiple-Choice Items?

- Any visual better than none.
- *Single most effective change we made to items:*
  - Adding visuals to illustrate answer choices
  - Especially answer choices with unfamiliar, non-technical words.

# Example of Visuals Added to Answer Choices

## Original

Which of the following objects is probably the **most** flexible?

- A. a **ceramic** dish
- B. a wooden block
- C. a short steel rod
- D. a new rubber **hose**

MA DOE 2005

## Revised

Which of the following objects is probably the **most** flexible?



A. a ceramic dish



C. a short steel rod



B. a wooden block

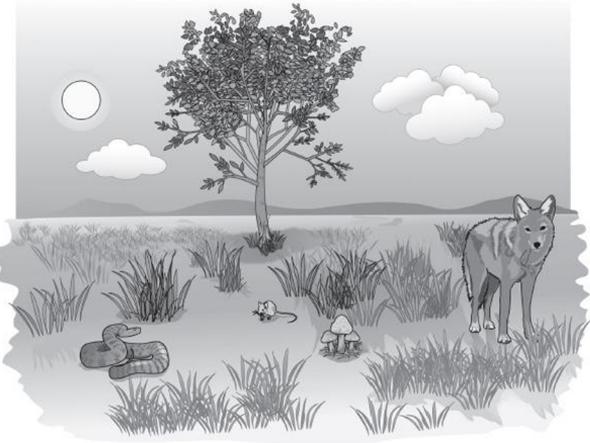


D. a new rubber hose

# Which visuals can help in Constructed-Response Items?

Visuals of things you need to include in your answer.

10 A prairie ecosystem includes many different organisms, such as grasses, coyotes, trees, mushrooms, snakes, and mice, as shown in the picture below. The energy needed by all the organisms in the ecosystem comes from one primary source.

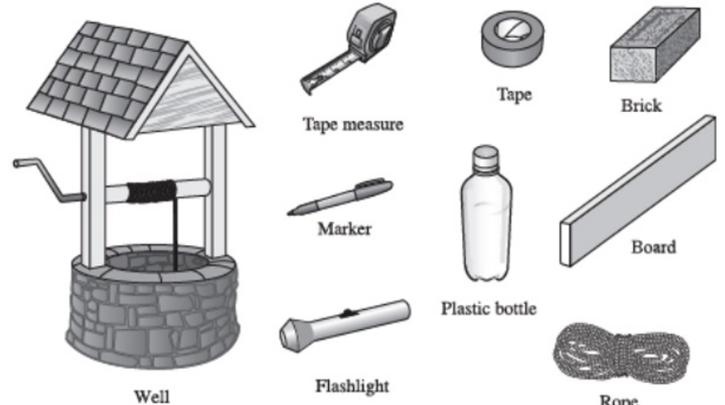


a. Identify the primary source of energy in the prairie ecosystem.

b. Identify one producer, one consumer, and one decomposer shown in the picture of the prairie ecosystem.

c. Explain how the energy from the primary source you identified in part (a) moves through the prairie ecosystem. Be sure to include producers, consumers, and decomposers in your answer.

19. Rosa wants to measure the depth of the well in her backyard. To help her find the depth of the well, Rosa gathered her tape measure and several objects from around her house. Her tape measure is 12 ft. long, but the well is deeper than 12 ft. The well and the objects that Rosa gathered are shown below.



a. Identify which of these objects Rosa can use with her tape measure to find the depth of the well.

b. Explain how Rosa can use her tape measure and **each** object you identified in part (a) to find the depth of the well.

# Why do we think Visuals Can Help ELs?

**Visuals provide additional, non-linguistic information to help ELs comprehend the text and potentially to support their writing.**

# **4. Writing is Harder than Selecting an Answer**

# How to measure the Writing Demand of Constructed-Response Items?

One test item we coded for writing demand

- 7 The picture below shows a battery-powered electric car. The chemical energy in the battery is changed into electrical energy when the car is being driven. The electrical energy is then changed into other forms of energy in the car.



- a. Identify **three** parts of the car that use electrical energy.
- b. Describe how electrical energy changes into another form of energy in **each** part of the car you identified in part (a).

(MA DESE, 2012)

# We looked at the two sample student responses scoring 4 points (maximum score)

- a. One part is the radio, another is the heater and a third is the lights.
- b. For the radio, the radio is hooked up to some wires that lead to the battery. While the car is on, the chemical energy in the battery changes to electrical energy and the electrical energy changes to sound energy, in the radio. The heater is the same thing; it is connected to the battery through wires and then when the car is on, the chemical energy changes to electrical energy which changes to heat energy. Lastly, the lights are connected to the battery, which is chemical energy and when the car is on, it is electrical energy which changes to light energy and heat energy.

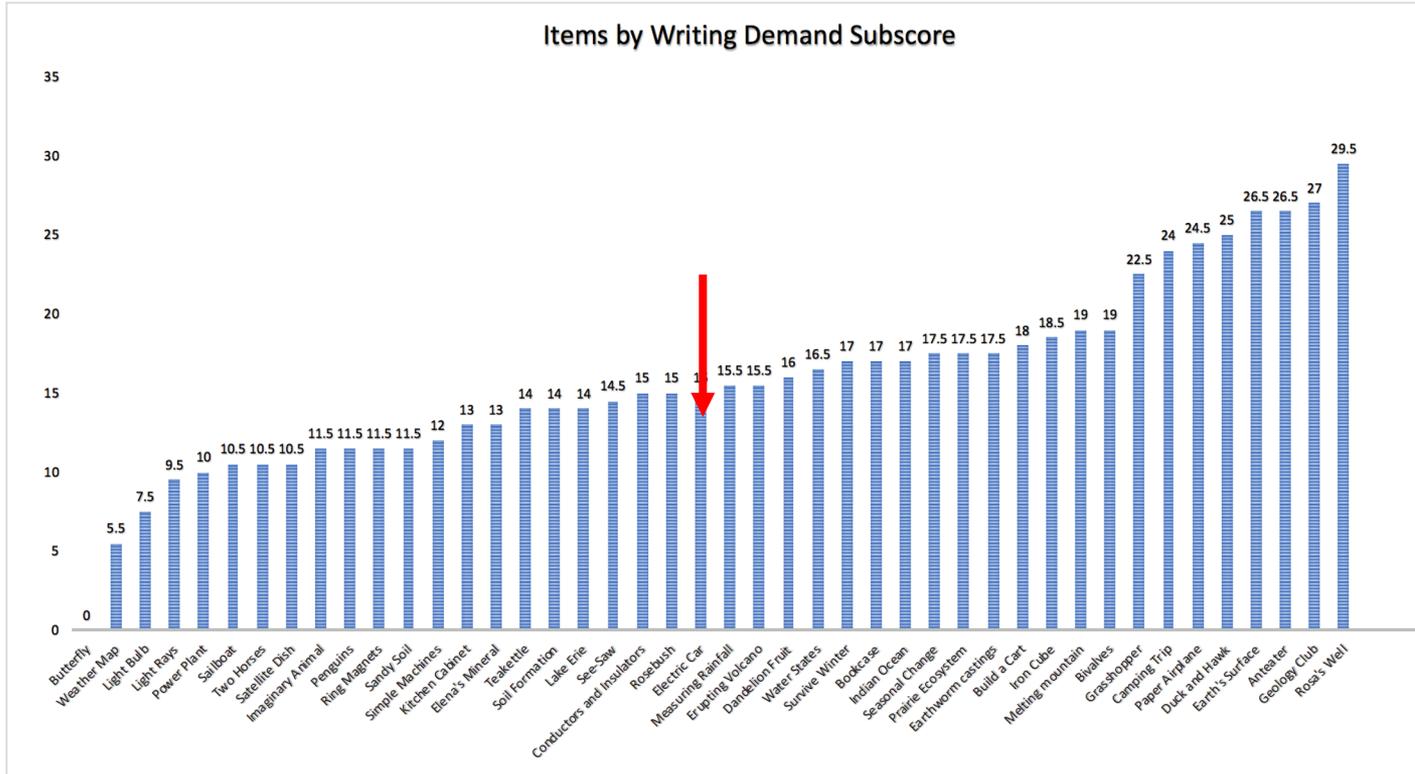
**18 clauses**

**Average =  
15 clauses**

**12 clauses**

- a. Three parts of the car that use electrical energy are the windshield wipers, windows, and lights.
- b. The windshield wipers change from electrical to mechanical because they are being controlled. The windows change from electrical to mechanical because you can control them by a switch. The front and back lights change from electrical to light and heat because if you turn them on they will light up and if you touch them after they have been on for along time it will be hot.

# Electric Car item writing demand score

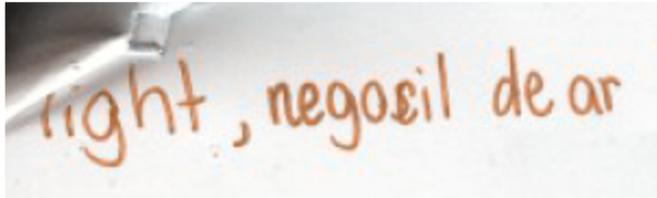


# How do EL students respond to the writing prompts?



- Identify three parts of the car that use electrical energy.
- Describe how electrical energy changes into another form of energy in each part of the car you identified in part (a).

## Gail, ACCESS Level 2.8



Light, *negocil de ar* [thing of air]

## Ester, ACCESS Level 4.3

- 1 there is the Gas tank that helps the car not die And so it could keep going.
- 2 the wheels help the car move so it could go places and so it helps the car move in Different Directions.
3. the lights Helps the ear by seeing whats in the way or to see if the car is working good.

**We found that ELs scored lower compared to non-ELs on Constructed-Response Items with higher Writing Demands.**

**Why?**

**ELs may have science knowledge they are not able to share in this format, but may be able to share in other ways in the classroom.**

## **5. Mismatch between how ELs can show science understanding in the classroom and how ELs can show science understanding on tests**

# How are Grade 5 ELs at different ACCESS levels reading in the classroom?

**EXAMPLE CONTEXT FOR LANGUAGE USE:** Students explore a variety of informational texts and media to discover how Earth's rotation around the sun affects shadows, day and night, and the phases of the moon and extract pertinent information to create a class book to share with first grade reading buddies who are also exploring day and night in science.

<b>COGNITIVE FUNCTION:</b> Students at all levels of English language proficiency ANALYZE the effects of Earth's rotation.						
	<b>Level 1 Entering</b>	<b>Level 2 Emerging</b>	<b>Level 3 Developing</b>	<b>Level 4 Expanding</b>	<b>Level 5 Bridging</b>	
<b>READING</b>	Identify words and phrases associated with Earth's rotation and day and night. <b>Identify words and phrases</b>	Sort words and phrases associated with Earth's rotation from illustrated texts (e.g., illustrated books, media, posters) using graphic organizers with a partner	Categorize sentences associated with Earth's rotation from a variety of texts (e.g., books, media) using graphic organizers with a partner	Organize sentences associated with Earth's rotation from a variety of texts using graphic organizers with a partner. <b>Organize sentences</b>	Order paragraphs associated with Earth's rotation from a variety of texts	<b>Level 6 - Reaching</b>
<b>TOPIC-RELATED LANGUAGE:</b> Students at all levels of English language proficiency interact with grade-level words and expressions, such as: Earth's rotation, phases of the moon						

# What supports are Grade 5 ELs receiving?

**EXAMPLE CONTEXT FOR LANGUAGE USE:** Students explore a variety of informational texts and media to discover how Earth's rotation around the sun affects shadows, day and night, and the phases of the moon and extract pertinent information to create a class book to share with first grade reading buddies who are also exploring day and night in science.

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READING	Identify words and phrases associated with Earth's rotation	Sort words and phrases associated with Earth's rotation	Categorize sentences associated with Earth's rotation from a variety of texts (e.g., books, media) using graphic organizers	Organize sentences associated with Earth's rotation from a variety of texts (e.g., books, media, encyclopedias) with a partner	Order paragraphs associated with Earth's rotation from a variety of texts	
	illustrated texts with a partner	books, media, posters)				
	manipulatives	graphic organizers		with a partner		
<b>TOPIC-RELATED LANGUAGE:</b> Students at all levels of English language proficiency interact with grade-level words and expressions, such as: Earth's rotation, phases of the moon						

# Compare with Constructed-Response Test Item: Earth's Surface

18. The surface of Earth is always changing. Some natural processes change Earth's surface slowly over time and others change Earth's surface very quickly. The picture below shows an area of Earth's surface that was shaped by natural processes.



©Royalty-Free/Corbis

Name and describe **three** natural processes that might have helped to shape this area.

(MA DOE, 2007)

# What supports are Grade 5 ELs receiving for writing in the classroom?

**EXAMPLE CONTEXT FOR LANGUAGE USE:** Students examine the impacts of exploration on both the old and new worlds (e.g., pretend you are an explorer writing a letter home or in your journal) after participating in a large group activity to map the spread of plants, animals, diseases, and riches in the age of exploration.

**COGNITIVE FUNCTION:** Students at all levels of English language proficiency **EVALUATE** effects of exploration on history.

	Level 1 Entering	Level 2 Emerging	Level 3 Developing	Level 4 Expanding	Level 5 Bridging	Level 6 – Reaching
<b>WRITING</b>	illustrated word banks in home language or English		Describe and give examples of positive and negative impacts of exploration using graphic organizers and word banks	Explain and give specific examples of positive and negative impacts of exploration using graphic organizers	Critique impacts of exploration and give detailed examples (e.g., new discoveries v. loss of native culture, freedom, life)	
	map) and illustrated word banks in L1 or L2					

**TOPIC-RELATED LANGUAGE:** : Students at all levels of English language proficiency interact with grade-level words and expressions, such as: colonization, explorers/ exploration, discover/discovery, conqueror/conquest

# Example Constructed-Response Test Item

## Earth's Surface

18. The surface of Earth is always changing. Some natural processes change Earth's surface slowly over time and others change Earth's surface very quickly. The picture below shows an area of Earth's surface that was shaped by natural processes.



©Royalty-Free/Corbis

Name and describe **three** natural processes that might have helped to shape this area.

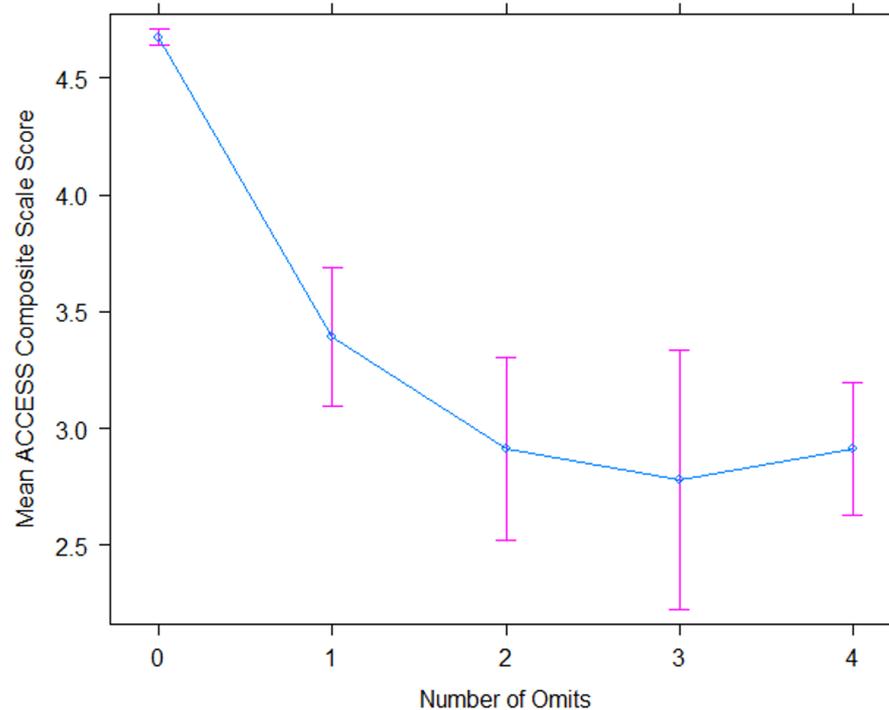
(MA DOE, 2007)

# Earth's Surface and other Constructed-Response test items

- Have reading and writing expectations beyond WIDA expectations for ACCESS Level 1 or 2 or 3 EL students
- Are mismatched with what ELs are doing in school to communicate what they know
- As a result, some ELs who know the science content may not be able to answer constructed-response test items

# MA ELs Skipping Constructed Response Items

2013 STE MCAS Data

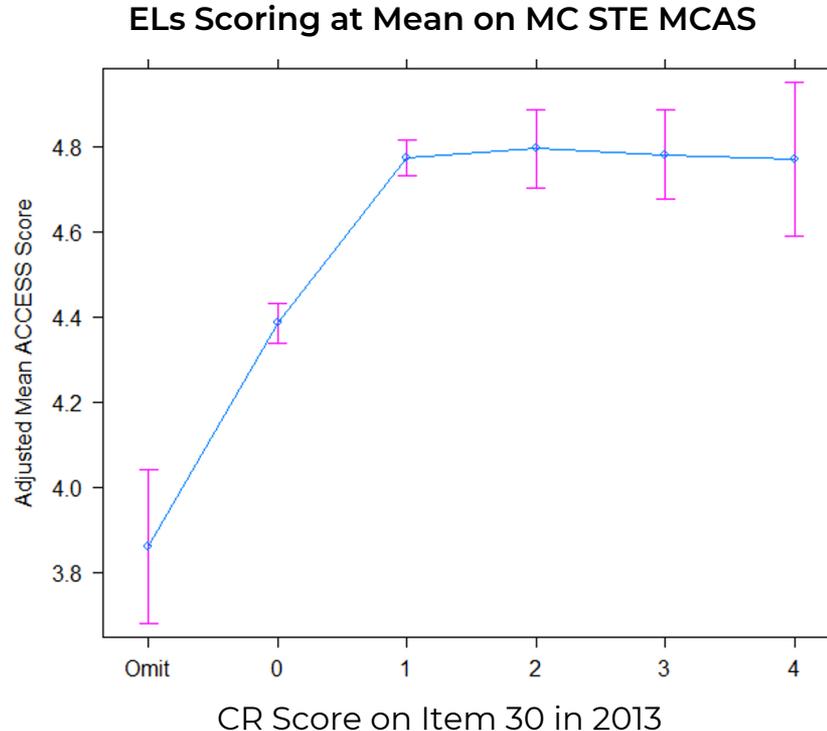


EL students  
at lower  
ACCESS  
levels skip  
more items →

# Why is this happening?

One possible explanation: The EL students scoring lower on the ACCESS test simply know less science.

That is  
**not**  
what  
the data  
show



# Similar Pattern in our Interview Studies on Constructed Response Items

- Interview Study 1 Method
  - Interviewed 103 Grade 5 EL, FEL, and Non-EL students
  - Each student wrote answers to 1-3 Constructed-Response Items
  - No accommodations allowed.
  - Asked a series of questions after students completed each item.

# Interview Study 1 Findings

- EL ACCESS Level 1 and 2 Interviewees wrote NOTHING for 28% of the Constructed-Response test items they saw.
- Students told us they could not understand what these items were asking them to do.

# Interview Study 2 allowed Accommodations

## Read Aloud in English\*

2. SPOKEN ITEM version – Use if student can answer when the item is read out loud in English

18. The surface of Earth is always changing. Some natural processes change Earth's surface slowly over time and others change Earth's surface very quickly. The picture below shows an area of Earth's surface that was shaped by natural processes.



©Royalty-Free/Corbis

Name and describe **three** natural processes that might have helped to shape this area.

## Read Aloud in First Language

3. TRANSLATED ITEM version – Use if student can answer when the item is read out loud in translation

18. SUPERFICE DE TERRA TA STA SEMPRE TA TROCA. ALGUNS PROCESSO NATURAL TA TROCA SUPERFICE DE TERRA DEVAGAR E OUTUS MUITO RAPIDO. KEL IMAGEM LI TA MOSTRA SUPERFICE DE TERRA KI FOI FORMADO PA PROCESSOS NATURAL.



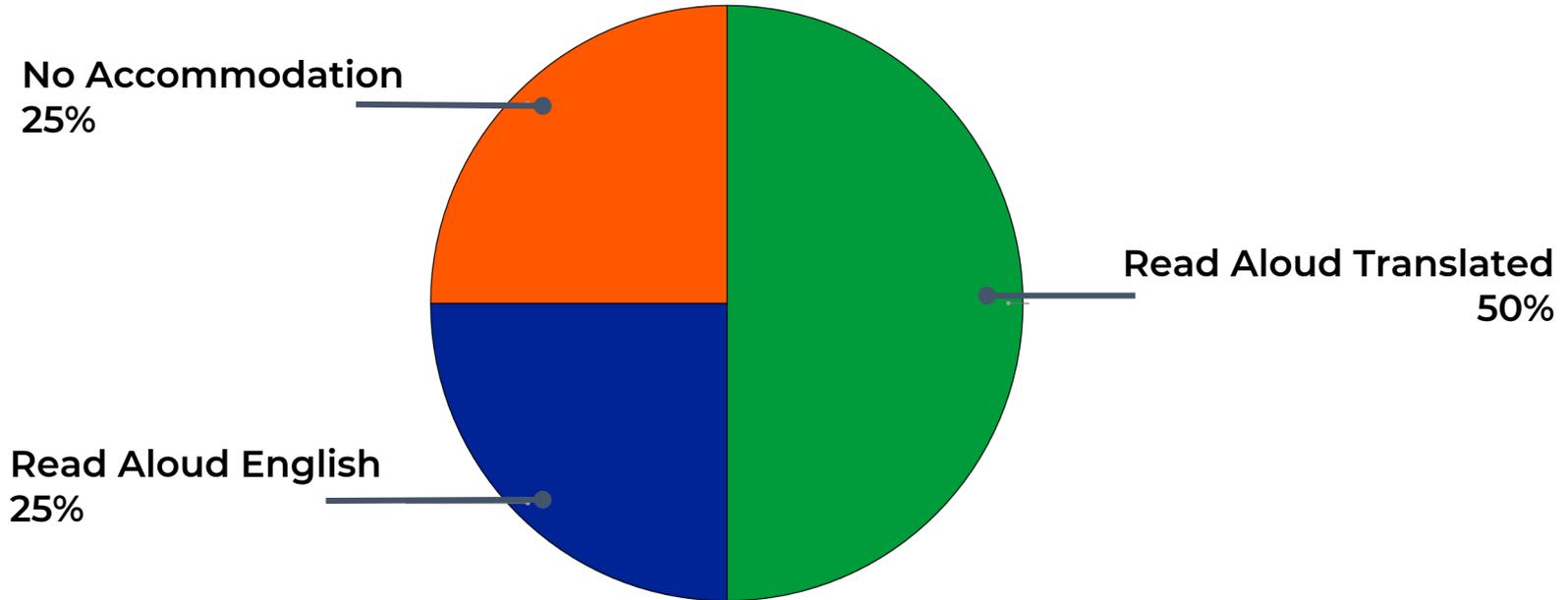
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FRAN E DESCREVE 3 PROCESSO NATURAL KI PODE DJUDA FORMA ES AREA.

\* Allowed by MA DESE

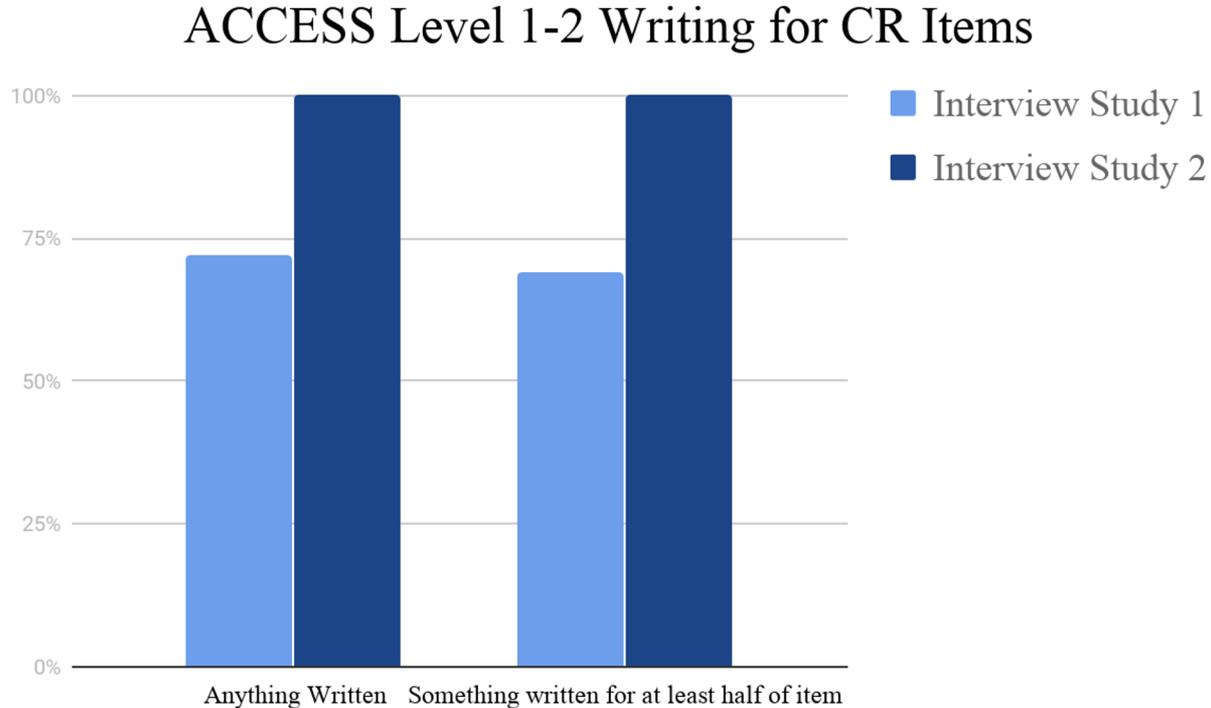
# Constructed-Response Test Items

Accommodation Used for ACCESS Level 1-2 ELs



# Constructed-Response Test Items

## Interview Studies 1 and 2 Findings



# **5 Main Takeaways for Assessment, Curriculum, & Instruction**

# Takeaway 1

## Words matter and familiarity is key

- Include helpful Technical words learned in school
- Avoid unhelpful Unfamiliar Non-Technical words not taught in school or illustrate these words

# Takeaway 2

## How words are put together matters

- Try to avoid Forced Comparison pattern or make sure it is explicitly taught
- Try to avoid Reference Back pattern

# Takeaway 3

## Visuals can help, but it depends on what kind and where

- Use visuals to illustrate answer choices
- Use visuals to illustrate unfamiliar non-technical words
- Use visuals to illustrate things students need to write about

# Takeaway 4

## Writing may not demonstrate what ELs know about science

- Expand options for students to show what they know in assessment contexts
  - Drawings with labels
  - Writing in first language
  - Speaking in first language and/or English\*

\* Allowed by MA DESE

# Takeaway 5

## Expectations of assessments may preclude participation of some ELs

- Testing accommodations based on ACCESS level are needed, such as:
  - Item read aloud in English\*
  - Item read aloud in translation
  - Graphic organizers
  - Option to write answer in first language
  - Option to speak answer\*
  - Illustrated Glossaries

# Conclusion

## Assessing what ELs know in science *in English*

- Takes place at the intersection of two domains of learning — English and Science.
- Student performance depends on both English proficiency and science knowledge.
- An item assessing students' English language proficiency rather than science knowledge is not a valid measure of science knowledge.

# Resources

- Hudicourt-Barnes, J., Noble, T., O'Connor, M. C., Rosebery, A. S., Suarez, C. & Warren, B. (July, 2010) *What do Standardized Science Tests Measure?: Children and Science Tests*. Presentation given to MA DESE. [Powerpoint of What do Standardized Science Tests Measure?](#)
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- Noble, T., Sireci, S. G., Wells, C. S., Kachchaf, R. R., Rosebery, A. S., & Wang, Y. C. (2020). Targeted Linguistic Simplifications of Science Test Items for English Learners. *American Educational Research Journal*. <https://doi.org/10.3102/0002831220905562>
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# Thank you

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