

## Module 5: Workshop 13

### Lesson Plan

<b>Overall Learning Goals</b> Strategies for Developing Common Core Skills in Content Areas (Math & Science): to train administrators and adult educators <i>to develop test readiness strategies</i> to further cement Common Core skills in content areas to better prepare their ESOL, ABE, and pre- HSE student constituency for the TASC exam.	<b>Lesson Topic</b> What are the Common Core instructional shifts in Math and Science? How do we see the instructional shifts reflected in sample assessment questions?
<b>Curriculum Developer</b> Tyler Holzer  <b>Workshop Trainer</b>	<b>Date</b>  <b>Location</b>
<b>Intended Audience</b> <ul style="list-style-type: none"> <li><b>Instructors</b> (content was designed as a workshop for Instructors).</li> <li>Note: Sample student material is included for Instructors to analyze during the workshop. Instructors may also use sample student materials in their classes.</li> </ul>	
<b>Standards Alignment</b> The Six Common Core Instructional Shifts in Mathematics: <ul style="list-style-type: none"> <li>Shift 1: Focus.</li> <li>Shift 2: Coherence.</li> <li>Shift 3: Fluency.</li> <li>Shift 4: Deep Understanding.</li> <li>Shift 5: Application.</li> <li>Shift 6: Dual Intensity.</li> </ul> NGSS Conceptual Shifts: <ul style="list-style-type: none"> <li>Shift 1: Science Education Should Reflect the Real World Interconnections in Science.</li> <li>Shift 2: Using Crosscutting Concepts to Teach Core Ideas.</li> <li>Shift 3: Science Concepts Build Coherently.</li> <li>Shift 4: Deeper Understanding and Application of Content.</li> <li>Shift 5: Science and Engineering are Integrated in Science Education.</li> <li>Shift 6: Science Standards Coordinate with English Language Arts and Mathematics Common Core State Standards.</li> </ul>	
<b>Goals and Objectives (SWBAT)</b> <ul style="list-style-type: none"> <li>Participants will know the six Common Core Instructional Shifts in Mathematics.</li> <li>Participants will know the rationale and research base behind these instructional shifts.</li> <li>Participants will know how to implement the instructional shifts in their classrooms.</li> <li>Participants will know how sample assessment questions relate to the six instructional shifts.</li> <li>Participants will know how the instructional shifts impact the teaching of science.</li> <li>Participants will become familiar with the Common Core instructional shifts in mathematics. <ul style="list-style-type: none"> <li>They will know how the instructional shifts came about in the wake of the TIMSS study, and they will learn about the TIMSS study's implications for teaching.</li> <li>They will leave with teaching strategies that help their students develop focus and coherence through rigorous lessons and problem-solving activities.</li> <li>Participants will also be able to analyze rigor on the TASC Readiness Assessment, and they will understand how teaching mathematics with applications to science can effectively prepare students for both subtests.</li> </ul> </li> </ul>	



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## Warm-Up/Review

- For group discussion: “Since the implantation of the TASC, what changes have you made in your instruction? What led you to make those changes?”
  - Participants should be divided up into groups or pairs so that they have the opportunity to share some of their classroom shifts with others.
  - While participants are working, the facilitator should check in with each group and ask guiding questions.
  - Participants will spend ten minutes discussing the questions in their small groups/pairs and write their findings on chart paper. The facilitator will ask groups/pairs to talk briefly about the changes they have made.
    - Participants will likely talk about two different kinds of shifts: shifts in content and shifts in teaching practice. Both of these topics are welcome, since they will be tied together later in the workshop.
    - The facilitator should ask participants how the changes in the content they teach are related to the changes they have made in their teaching practice.
- Once each group has had a chance to share, the facilitator should ask participants about which shifts have been the most difficult to make.
  - Question for discussion: “Which classroom changes have been the most difficult for you to make? Why have they been challenging?”
  - The facilitator should go around the room, and each participant should offer a response and a brief reason why.
- To end the warmup, the facilitator will tell participants that this workshop will address the instructional shifts set forth by the Common Core and the Next Generation Science Standards.
  - In order to support students taking the TASC, a Common Core–aligned exam, we need to make sure that our math and science instruction aligns with these instructional shifts.
  - In this workshop, we will analyze the Common Core Instructional Shifts in Mathematics, and we will also touch on the conceptual shifts in the Next Generation Science Standards.

## References (APA Style)

- Appleton, Eric. (2015, April 27). “A window into international education.” *CollectEdNY.org*. Retrieved from <http://www.collectedny.org/2015/04/a-window-into-international-education>.
- Hiebert, J. and Stigler, J. W. (2004). A world of difference: Classrooms abroad provide lessons in teaching math and science. *Journal of Staff Development*, 25(4), 10-15.
- Nguyen, F. (2014). *Visual Patterns*. Retrieved from [www.visualpatterns.org](http://www.visualpatterns.org).
- Smith III, J. P. (1996). Efficacy and teaching mathematics by telling: A challenge for reform. *Journal for Research in Mathematics Education*, 27, 387-402.
- Stigler, J. W. and Hiebert, J. (1999). *The Teaching Gap*. New York, Free Press.
- Takahashi, Akihiko. (2006). Characteristics of a Japanese mathematics lesson.” From a paper presented at the APEC International Conference, January 14-20.

## Technology and Handouts

### Technology Needs

- AV cart with projector, laptop, and speakers will be provided.
- Laptop or tablet computer for each student with access to Internet.
- Latest version of Adobe Flash installed on laptops.

### Presentation Needs & Handouts

- Chart Paper.
- Markers.

Each item listed below will be available in PDF format.

- Applied Math on the TASC Science Subtest.
- Characteristics of a Japanese Math Lesson.
- Difficult versus Rigor.
- NGSS Conceptual Shifts.
- Rigor on the TASC Mathematics Subtest.
- The Growing T Problem Intro.
- The Growing T Problem Lesson Plan.
- The Growing T Problem Students.
- The Growing T Problem Teachers.
- The Six Instructional Shifts in Mathematics.
- TIMSS Study
- Two Kinds of Functions Questions.
- Two Teaching Approaches.
- Ways of Seeing the Growing T.



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## Lesson Plan Activities

### Part 1: The TIMSS Study as a Foundation for the Common Core Instructional Shifts in Mathematics

#### Lesson Content

In the first part of the lesson, participants will learn about the findings of the Third International Mathematics and Science Study (TIMSS) and how it led to the development of the Common Core State Standards and the Six Instructional Shifts in Mathematics.

#### Lesson Materials

Handout outlining the findings of the TIMSS study.

#### Questions to Answer

- What is the significance of the TIMSS study?
- How can I make time for and support problem solving in my classroom?
- How can I scaffold problem-solving activities so that students have time to make conclusions on their own without me giving them the answer?
- How are the instructional shifts reflected in sample assessment questions in math and science?

#### Background/Opening

- The facilitator will begin the activity by providing background on the TIMSS study.
  - The Trends in International Mathematics and Science study has taken place several times, with the first study taking place in 1995. The discussion in this workshop will focus specifically on the Third International Mathematics and Science Study—this is the study about which Stigler and Hiebert wrote extensively in their book *The Teaching Gap*.
  - The goals of the TIMSS study are to investigate mathematics and science teaching practices in U.S. classrooms; to compare U.S. teaching practices with those found in high-achieving countries; to discover new ideas about teaching mathematics and science; and to develop new teaching research methods and tools for teacher professional development.
  - Schools were randomly selected in each country. One math lesson and one science lesson were videotaped at each school, and filming was spread out throughout the school year.
  - The highest-performing countries, throughout the years that the TIMSS studies were conducted, are Singapore, South Korea, Japan, Hong Kong, and Taiwan. The United States only entered the top 10 in the 2011 study (at number 10).
- Participants will read TIMSS study handout, and the facilitator will lead a discussion of the findings with the group.
  - In this particular study, the researchers conducted an in-depth analysis of mathematics instruction in Germany, Japan, and the United States.
  - What they found is that even though German classrooms and Japanese classrooms are very different, both countries showed high levels of achievement.
  - The main finding was that in Germany and Japan, the level of mathematics covered is at a much higher level than it is in the United States.
    - In Japan, teachers frequently focus instruction around one rigorous problem, and the students are given the opportunity to uncover significant mathematical theorems and ideas on their own. The teacher acts as a facilitator between the students and the mathematics.
    - In German classrooms, the teacher is the keeper of the knowledge. The teacher introduces a key concept, and students explore the concepts and theories while the teacher keeps everyone on track and chooses students to explain their thinking to the class.
  - The findings of the TIMSS study show that we need to devote class time to problem-solving, exploring connections, and discussing relationships.
  - It also shows that as teachers, we can better serve our students by resisting the impulse to step in, take the student's pencil, and do the work for them or provide them with a tidy pathway to the solution.
- After the group has had time to read through the handout on the TIMSS study, the facilitator should lead the group in a discussion of the findings.
  - Questions for discussion: “As a teacher, how do you feel about the findings of the TIMSS study?”
  - Does it describe practices for teaching that you haven't yet tried in your own classroom?
  - Do you feel okay about letting students struggle productively in the classroom?
  - When we teach, we always have the TASC in mind. How do you reconcile the findings from the TIMSS study with the realities of teaching students who want to pass a standardized assessment?”



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### Lesson Activities

- Activity 1: The facilitator will distribute the handout Two Teaching Approaches to One Concept for group analysis and discussion. The facilitator should begin by asking participants to read through the problem and both teaching approaches.
  - The authors point to method 1 as the most effective way of introducing this concept.
    - Question for discussion: “Which way would you typically teach an activity like this in your classroom?”
    - Participants should feel encouraged to point out that they often give students pathways to solutions—at certain times, all teachers have. As teachers of adults, we often feel crunched for time and recognize that our students need to be exposed to a breadth of content in order to pass the TASC. This can make it difficult to spend an entire class exploring the origins of a single formula.
  - For further discussion, the facilitator should ask participants to talk about the benefits of the first teaching method.
    - Questions for discussion: “What are the benefits of letting students measure some common figures and look for a pattern? How does method 1 allow students to make connections across mathematical content areas?”
    - Some participants may point out that method 1 reflects the Instructional Shifts in Mathematics, particularly **focus, fluency, and deep understanding**. These will be discussed in the next activity.
- Activity 2: For the last part of the lesson, the facilitator will distribute the Growing T Problem for Teachers handout. Participants should be given time to solve the problem individually. At this point in the activity, the participants should only work on solving the Growing T Problem. The facilitator should direct them to wait before moving onto the second part of the handout.
  - Participants should be given time to think about the problem individually. This will likely take some participants only a short time, while other participants will need some support from the facilitator. If some participants finish the activity early, the facilitator could ask the following extension question:
    - Extension: “What would be the perimeter of the 51<sup>st</sup> figure? How could you find the perimeter of the  $n$ th figure?”
    - In advance of the activity, the facilitator should solve the problem and think about ways to support participants who might be struggling with the problem.
    - The facilitator should also refer to the handout Ways of Seeing the Growing T Problem. This handout should not be shared with participants until after the activity has concluded.
  - If time allows, the facilitator should lead a discussion of solution methods.
    - Since participants who solved the problem successfully may not have seen it the same way, discussion of strategies should allow for different “seeings” of the problems. Different seeings may results in different functions used to find the number of squares in the  $n$ th figure. The facilitator may again choose to refer to the Ways of Seeing the Growing T Problem handout.
    - After participants have discussed the different ways of seeing the problem, the facilitator may choose to share the Ways of Seeing the Growing T Problem handout with the participants.
- Activity 3: In pairs or small groups, participants should work on the second part of the handout. Specifically, they should think of ways to structure and scaffold a problem-solving activity based on the visual pattern. They should develop specific questions that help students arrive at a rule without giving too much away.
  - The facilitator will point out that many students would not be able to solve the problem without scaffolding in place. Participants should be instructed to add additional questions to the activity so that students can work toward a clearer understanding of the pattern.
  - For example, participants may include questions that ask students to:
    - Sketch the next two figures;
    - Create a table of values for the first ten figures and look for a pattern;
    - Write about what they see changing in the pattern;
    - Describe a particular figure.
  - After groups have had time to think about the scaffolds they would put in place, the facilitator will ask each group to share one or two of their ideas. Groups should point out why those scaffolds would help students to understand the pattern more clearly and draw a conclusion about the  $n$ th figure.

### Wrap Up/Assessment

- The facilitator will lead the whole group in a discussion of the Growing T Problem and make connections to the findings from the TIMSS study discussed earlier.
  - The facilitator will guide participants back to the Two Teaching Methods for One Concept discussion. The traditional way of showing students how to solve the Growing T Problem might involve them giving students the formula and asking them to plug in a value for the variable. Some questions for discussion:



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- “How does this method of introducing the problem differ from what we might consider ‘the traditional way’ of introducing it?”
- “How does this method allow students to make discoveries on their own?”
- “How does it allow them to see connections across content areas?”
- The facilitator will distribute the handout The Growing T Problem Students. Participants will analyze the student version of the Growing T Problem and talk about the scaffolding in place on this version of the problem. Participants will consider whether their students will need more or less support than is already given.
  - For assessment, participants will write about the following prompt: “What did you like about this problem? How do you think it would work with your students?”
- If time allows, participants will also discuss adaptations of the problem, or other visual patterns that could be used to develop algebraic thinking and pattern recognition.
- The facilitator will recommend that participants try the student version of the Growing T Problem in an ABE or HSE class, noting that the goal for a higher-level class would be the creation of a function, while the goal for a lower-level class may be to describe what the  $n$ th figure would look like without using algebra.
- Participants should visit [www.visualpatterns.org](http://www.visualpatterns.org) and look for other linear visual patterns that could be used in their classrooms.
- For extended study, participants should read the CollectEdNY review of the TIMSS videos, located at <http://www.collectedny.org/2015/04/a-window-into-international-education/>. The review describes a particular math lesson and provides links to video and source material for the lesson itself.
  - Participants should also be encouraged to examine other reviews of mathematics resources on [www.collectedny.org](http://www.collectedny.org). The site is funded by NYSED and offers peer reviews of online instructional material in all subjects.

## **Lesson Part 2: Analyzing the Six Instructional Shifts in Mathematics**

### **Lesson Content**

In this lesson, participants will analyze the Six Instructional Shifts in Mathematics and how they apply to the ABE/HSE classroom. They will also explore the difference between a difficult problem and a rigorous classroom task.

### **Lesson Materials**

- Handout on the Six Instructional Shifts.
- Handout detailing Difficulty versus Rigor.
- Handout titled Two Types of Functions Questions.

### **Questions to Answer**

- What are the six instructional shifts, and what do I need to do to make them in my classroom?
- Which shifts have I already made?
- Which shifts do I need more support in order to make?
- What is rigor, and how does it differ from difficulty?
- How can I ensure that I am using rigorous tasks in my mathematics classroom?

### **Background/Opening**

- The facilitator will introduce the Six Instructional Shifts in mathematics and distribute the accompanying handout.
  - In order to be aligned with the Common Core and with existing curriculum materials, teachers must make changes in their classroom instruction.
  - The main thrust of the shifts is to help teachers understand that their instruction should be “an inch wide and a mile deep,” rather than a mile wide and an inch deep. Teachers should also work to draw explicit connections between mathematical concepts and encourage application of key skills.
  - The Six Instructional Shifts were developed in large part as a response to the TIMSS video study, which showed that students achieve at higher levels when instruction is focused and coherent, and when students are given ample time to solve complex problems as opposed to drilling specific skills divorced from context.
  - Question for discussion: “How would the Six Instructional Shifts come into play when using problems like the Growing T Problem?”
    - The problem promotes **focus** because it involves spending lots of classroom time on one activity. The problem helps build understanding of patterns and functions through a series of scaffolded activities.
    - It also promotes **coherence**. In whole-class discussions of solution methods, the teacher has the opportunity to point out how different “seeings” of the problem produce the same result, and the class can then spend time



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exploring why this is the case.

- The problem encourages **fluency** by asking students to notice patterns and perform quick calculations to determine how many squares would be in a given figure.
- It promotes **deep understanding** through extended involvement with the problem. Students are not given the formula and asked to plug in numbers; instead, they are tasked with uncovering a formula that they could use.
- The problem builds skills that can be **applied** in other context, but while solving the Growing T, students also have to apply prior knowledge about patterns and mathematical operations.
- The problem is an excellent example of an activity that promotes **dual intensity**. To solve it successfully, students must think deeply about the mathematical pattern while performing calculations to check their work. In short, they are building conceptual understanding while attending to precision.
- As participants respond to the question, the facilitator will record responses on the whiteboard or on chart paper.

### Lesson Activities

- Activity 1: The facilitator will direct participants back to the list of shifts that they have already made—from the warm-up activity—and align them with the shifts set forth by the Common Core.
  - During this activity, the facilitator will list each of the Six Instructional Shifts in Mathematics on chart paper or on the board.
  - Participants will in pairs or small groups to place the classroom shifts that participants have already made within one of the six instructional shifts. The facilitator should note that some teaching practices may fall under more than one of the shifts.
  - The facilitator will then encourage participants to identify instructional shifts that they may not yet have implemented in their classrooms, and will lead a discussion in which each small group shares the shifts they hope to implement in their classrooms, and the activities/practices they would incorporate in order to make those shifts.
    - Question for discussion: “What are some activities you might try in order to make these shifts?”
- Activity 2: After the discussion of shifts, the facilitator will introduce the concept of *rigor* and differentiate it from *difficulty*.
  - Question for discussion: “How do you interpret ‘rigor’ as it applies to mathematical tasks?”
    - The facilitator should point out that difficulty is a relative concept. For example, solving a multistep linear equation is, for many of us, a very easy task. For our students, however, it can be a very difficult task. Solving equations, though, isn’t necessarily rigorous.
    - Rigor involves making connections and having deep command of mathematical concepts. As it relates to the example of solving linear equations, many students may be able to solve an equation, but not all students understand the processes and concepts that underlie the task.
  - After discussion, the facilitator will distribute the handout Difficulty versus Rigor. Participants will read through the characteristics of difficult tasks and rigorous tasks.
- Activity 3: Participants will reflect on the difference between a difficult mathematical task and a rigorous mathematical task by analyzing the handout Two Kinds of Functions Questions.
  - The first type of function question would be difficult for most students, in that it involves paying careful attention to exponents and negative signs. This question wouldn’t be considered a rigorous task because it doesn’t develop understanding of functions. Instead, it just asks students to crunch numbers. If a student accidentally misses a negative sign, then their entire answer is wrong.
    - The facilitator should point out that there are difficult tasks on the HSE exam, and difficult tasks can have value in the classroom. As teachers, we need to shift the balance in favor of rigorous tasks.
  - The second function question exposes students to three different views of a function—a table, a graph, and a rule—and it requires extended thinking. The problem helps students to see connections between the three representations through a scaffolded approach.
  - After participants have had time to reflect on the mathematical tasks, the facilitator will lead the group in a discussion of why the rigorous problem is more rigorous.

### Wrap Up/Assessment

- Facilitator will lead a closing discussion on the Six Instructional Shifts.
  - Question for discussion: “In terms of lesson planning and classroom teaching, what are the benefits of being mindful of the Six Instructional Shifts in Mathematics?”
- Assessment: In a five- to ten-minute free-write, participants will individually reflect on the Six Instructional Shifts and write about changes that they plan to make in their classrooms in the future.
  - Question for reflection: “Think of something you want try in the classroom. How would this activity reflect the



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instructional shifts?”

### **Lesson Part 3: Analyzing Rigor on the TASC Mathematics Subtest**

#### **Lesson Content**

The workshop will continue to analyze the concept of rigor as it applies to the types of questions that would appear on the mathematics subtest of the TASC.

#### **Lesson Materials**

Handout Rigor on the TASC Mathematics Subtest

#### **Questions to Answer**

- How do we see the instructional shifts reflected in assessment questions?
- How can I use the Six Instructional Shifts in Mathematics to ensure that my teaching focuses on the types of rigorous questions that students will encounter on the TASC?

#### **Background/Opening**

- The facilitator will lead a discussion of rigor as it applies to the TASC.
  - As noted in the previous activity, rigorous classroom tasks can take extended periods of time, and teachers should emphasize deep understanding of the concepts underlying the task.
  - On the TASC, most problems will not require the same amount of time and involvement as a classroom task might, but students should still be prepared to struggle with problems that require deep understanding and connections between concepts or skills.
  - By adopting the six instructional shifts in our classrooms, we can give students the deep understanding they need to answer TASC questions that fall into Webb’s Depth of Knowledge levels 2 and 3.
- The facilitator will ask participants about their experience with the 2014 and 2015 versions of the TASC Readiness Assessment.
  - It is likely that some participants will not be familiar with the Readiness Assessments. In this case, participants who are well-versed in the tests should be invited to offer their opinions for the group to consider.
  - Ideally, participants will point out that the first version of the Readiness Assessment contained primarily difficult—but not necessarily rigorous—questions. Many did not involve the application of concepts or deep understanding of mathematical ideas. Instead, the bulk of the questions asked students to demonstrate a particular skill.
  - By contrast, the 2015 Readiness Assessment includes more questions that have multiple entry points, and the pathway to the solution isn’t always clear. Test-takers have to think more creatively about how to solve problems.

#### **Lesson Activities**

- Activity 1: The facilitator will distribute the handout Rigor on the TASC Mathematics Subtest. Both of these problems are very similar to those on the 2014 and 2015 Readiness Exams, respectively.
  - Participants will first solve the low-rigor problem on the first page of the handout.
    - Solving the problem should only take a minute or two. There is only one way to solve this problem—plugging in a value for  $x$  and arriving at a numerical answer.
- Activity 2: After participants have solved the problem, the facilitator should ask for a volunteer to show their work on the whiteboard.
  - The facilitator should ask the volunteer to explain their thinking as they write out their work.
  - The facilitator might also ask questions about what made the problem challenging, or, in this case, what made it easy.
    - Once the participant has finished, the facilitator should ask the group if anyone used any other strategies to solve the problem. Because there is only one way to solve the problem, all participants should say that they solved it the same way, with little variation.
    - Because of the straightforwardness and relative ease of the problem, this is a low-rigor task. It doesn’t invite creative thinking or conceptual understanding.
- Activity 3: Participants should then turn to the high-rigor functions question on the second page. Because this problem is much more challenging and cognitively complex, participants will not be able to solve it as easily.
  - The facilitator should give participants plenty of time to work on the problem and should offer support in the form of questions when participants are struggling.
  - At the facilitator’s discretion, participants may be allowed to work in pairs to solve the problem.
    - This problem is more rigorous because the solution pathway isn’t clear, and the graphs will require some



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investigation on the part of the student. The problem ties together the representation of a function as an equation and as a graph.

- Some information can be deduced from the shapes of the curves, though not all students would be able to make these connections. Because the leading term is positive, the graph should initially be increasing. Also, because it is a polynomial of degree 3, the graph cannot be a parabola. Certain choices can be eliminated this way.
- All four graphs have the same  $y$ -intercept. This makes it hard to use  $f(0)$  to learn about which graph could be correct. Therefore, students need to plug values of  $x$  into the function and find the corresponding  $y$  values. This requires students to understand that the input of a function and its corresponding output form an ordered pair. Students would need to test at least one nonzero input in order to choose the correct graph.
- Activity 4: When all participants are finished working, the facilitator will ask for another volunteer to talk about their thinking in solving this question.
  - As with the previous problem, the facilitator should ask clarifying questions and ask participants if anyone tried any other strategies.
    - The facilitator should ask questions that draw out vocabulary like “ $y$ -intercept” and “shape of the curve.”
    - The facilitator should also elicit discussion about different approaches to the problem.
    - Question for discussion: “Where did you struggle with this problem? What was your thought process as you were struggling?”
- Activity 5: After the processing of the solution, participants will look back to the Six Instructional Shifts handout and indicate which shifts are reflected in the rigorous version of the problem.
  - Participants should be guided to think about the instructional strategies involved in building content knowledge for the problem, and they should think about ways to teach multiple approaches to the problem.
  - In addition to thinking about conceptual understanding, participants should think about which computational skills/strategies (fluency) would be needed to solve the problem in a test environment.
  - Participants will share their responses with the group in a discussion format.

#### **Wrap Up/Assessment**

- Individually, participants will further reflect on the Six Instructional Shifts and the implications they have for teaching students preparing for the TASC.
  - Question for assessment: “One of my biggest challenges in helping students to understand and solve rigorous problems is \_\_\_\_\_. In future lesson, I plan to try \_\_\_\_\_.”
  - Participants should think about the prompt and write for about five minutes. When everyone has finished, the facilitator will ask volunteers to share what they wrote.

### **Lesson Part 4: Analyzing Applied Mathematics on the TASC Science Subtest**

#### **Lesson Content**

Participants will continue unpacking the Six Instructional Shifts in Mathematics by examining how they apply to the science subtest. Participants will solve and discuss two applied mathematics problems and discuss the teaching implications for each.

#### **Lesson Materials**

Handout of sample science assessment questions with applications to mathematics.

#### **Questions to Answer**

- How can we effectively teach key science standards through mathematics applications?
- What do applied mathematics questions on the science subtest look like?

#### **Background/Opening**

- At this point in the workshop, the facilitator will shift the focus toward an analysis of science assessment questions and how the Instructional Shifts in Mathematics have implication on the teaching of science.
  - Question for discussion: “How can the instructional shifts in mathematics impact our teaching of science topics?”
  - Participants should share their thoughts in a discussion format.
    - Focus, coherence, application, and deep understanding are particularly relevant to the teaching of science. For many teachers who cover all five TASC subjects in a class that meets two or three days each week, it is crucial to make sure that science content is chosen carefully and covered in depth.
    - We also see the Standards for Mathematical Practice reflected in science assessment questions. Students need to be able to make sense of complex situations and persevere in solving them, much like they do on the math test. The science test also requires students to use the calculator when appropriate.



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- The facilitator will distribute the handout Next Generation Science Standards Conceptual Shifts for brief discussion.
  - The facilitator and participants will read through each of the standards and establish connections between the NGSS Conceptual Shifts and the Common Core Instructional Shifts.
    - Both sets of standards place a strong emphasis on the **application** of concepts and **deep understanding** of topics. Both specify that content knowledge should build **coherently** and emphasize connections.
    - Crosscutting concepts are those that provide students with skills and knowledge that can be applied across disciplines. According to the NGSS, they are: patterns; cause and effect; scale, proportion, and quantity; systems and system models; energy and matter; structure and function; and stability and change.
  - The facilitator should point out that the NGSS Conceptual Shifts also reflect the findings of the TIMSS study. The TIMSS showed that the United States is falling behind other countries in science instruction. In United States classrooms, science topics have traditionally not been rigorous enough and have not emphasized deep understanding of key science concepts. The NGSS set out to address this.
- Before looking at sample assessment questions, the facilitator should poll the group about their level of familiarity with the science Readiness Test.
  - Question for discussion: “Has anyone taken the science Readiness Tests? What do you remember about the questions that involved mathematics?”
    - Both the 2014 and 2015 Readiness Tests contain applied mathematics, and they involve varying levels of rigor and difficulty. The questions on the Readiness Test and the sample questions posted online often contain graphs and tables, along with formulas that test-takers should apply to the data presented.
    - These questions should guide the group toward a discussion of applied mathematics in general.

### Lesson Activities

- Activity 1: Participants will solve two applied math problems similar to those that would appear on the TASC science subtest.
- Activity 2: The facilitator will distribute the handout Applied Math on the TASC Science subtest.
  - The facilitator should give participants five to ten minutes to solve the problem. The facilitator should provide support as necessary.
    - This problem might be challenging for students because the value for acceleration is not given explicitly in the problem. Students need to analyze the table and notice that acceleration is equal to the rate of change in velocity. In this case, the velocity increases by 3 each time  $t$  increases by 1, which means that the acceleration is 3 meters per second squared.
    - Students will then need to plug this value, along with the mass  $m$ , into the formula  $F = ma$ . This problem is a little less straightforward than some simple physics questions because the value for  $F$  is given and the student must solve for  $a$ .
- Activity 3: When the participants have finished solving the problem, they should share their answers and their thinking with a partner.
  - The facilitator should then ask participants to reflect as a group on what made the problem challenging.
    - Question for discussion: “What did you notice about this problem? What might make this problem challenging for students?”
- Activity 4: After the discussion, the facilitator should then instruct participants to turn the handout over and solve the problem on the second page.
  - When participants are finished working on the problem, the facilitator should again ask participants to talk about what might be challenging for students who see a similar problem on the TASC.
    - Question for discussion: “What aspects of this problem might students find challenging?”
    - In this case, test-takers need to look at a graph and understand that the species population is decreasing as a result of deforestation. This is not explicitly stated in the problem. Students then need to analyze the total amount of deforestation, as well as the proposal for restoring forest lands. In this problem, the proposal would add more square miles of forest than is currently being deforested, so the bird population should rise. This increase would be very gradual, though, because there would only be a net increase of 5 square miles of forest land each year. Students would need to do the math correctly and make an inference based on the numbers.
- Activity 5: The facilitator will lead a discussion of how these problems reflect the Six Instructional Shifts in mathematics.
  - Question for discussion: “How do we see the Six Instructional Shifts in Mathematics reflected in problems like these? How do we see the NGSS Conceptual Shifts reflected in these problems?”
    - Participants should be directed to look back at the Six Instructional Shifts handout and look for specific language in the shifts that would apply to these problems. Possible responses and suggestions for furthering the



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discussion are:

- Problems like these emphasize the **application** of mathematical topics. Students must be **fluent** in basic algebra, and they must be able to quickly read and interpret charts, tables, and graphs. These problems also cannot be solved through tricks—they require **deep understanding** of mathematical content, even though the computations might be rudimentary. In terms of our teaching, these sorts of problems call for **coherence** in instruction; that is, teachers should connect learning not only across topics, but across disciplines as well, whenever possible.
- In terms of the NGSS Conceptual Shifts, these problems focus on **deep understanding** and **application** of content. The first problem requires students to know how velocity relates to acceleration and apply it to a formula. The second problem reflects the NGSS Conceptual Shifts in that it emphasizes the **interconnected nature of science in the real world**. Here, students must draw conclusions about a real-world situation involving sustainability and ecology.

### Wrap Up/Assessment

- The facilitator will lead a closing discussion about the benefits of interdisciplinary lessons.
  - An interdisciplinary approach to teaching math would involve applying math concepts to situations in the sciences. Taking an interdisciplinary approach to teaching mathematics allows teachers to maximize their time with students by touching on more than one subject in a single lesson. For example, math could also be applied in teaching the fundamentals of supply and demand in economics. This is an example of coherence in lesson planning and instruction.
  - Question: “What are some ways that we could fold the teaching of science into our mathematics instructions? What would be the challenges? The benefits?”
- For assessment, the participants will answer the following prompt, which they will share with the group at the end of the lesson.
  - Prompt: “Being mindful of the NGSS Conceptual Shifts and the Common Core Instructional Shifts will make me a better science teacher because \_\_\_\_\_.”

### Overall Wrap Up

*Note: this part will be done in a discussion format.*

- What is something we worked on today that you would want to try in your classroom?
- What kinds of support will you need to feel comfortable preparing students to pass the math and science subtests on the TASC?
- What is something we discussed in this workshop that you would be interested in exploring further?

### Project/Homework

- Participants will create sample math exercises that have applications to science. Their responses will be shared with other participants in the workshop via email, Wiggio, etc.
- Participants will read “Characteristics of a Japanese Math Lesson.”
- For further reading, participants should read Stigler and Hiebert’s “A World of Difference.” Interested participants should be directed to their book *The Teaching Gap*, which offers a more complete description of the TIMSS study, its findings, and its implications for teaching and professional development in the United States.



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