College and Career Readiness Standards-in-Action

ADVANCED UNIT

3

VIDEO RESOURCE PAK FOR MATHEMATICS

OBSERVING COLLEGE AND CAREER READINESS STANDARDS-IN-ACTION

Video Features:
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INTRODUCTION

Today's adult educators are asking important questions about college and career readiness (CCR) standards: What do lessons look like that are aligned with these standards? How should this instruction differ from instruction that was tied to previous sets of standards?

Advanced Unit 3, Observing CCR Standards-in-Action (SIA), begins to answer these questions. It offers educators the training and tools they need for observing effective practices in teaching and learning that reflect the instructional advances of CCR standards, including an examination of lesson content, instructional practices, and classroom assessments.

The video lesson of one instructor, Richmond Onokpite, and the accompanying tools included in this Video Resource Pak provide additional guidance and concrete, visible evidence of CCR standards-aligned lessons. To help viewers use the CCR SIA Classroom Observation Tool, specifically, for Richmond's lesson, this resource includes the following elements:

- A set of guiding questions tied to each Core Action.
- A completed CCR SIA Classroom Observation Tool that identifies the steps Richmond takes, student responses to his instruction, and standards-aligned lesson elements.
- Richmond's lesson plan, which identifies the targeted CCR standards, learning goals, and sequence of planned activities.

Core Actions of the CCR SIA Classroom Observation Tool:

Core Action 1. Curriculum content of the lesson matches the demands of CCR standards.

Core Action 2. Learning activities (questions and tasks) are challenging and maximize opportunities for students to master the lesson content.

Core Action 3. CCR standards are translated into lesson content that productively engages adult learners.

Core Action 4. The lesson is intentionally sequenced to build on and develop students' skills and knowledge of specific content.

Core Action 5. Students' levels of understanding are assessed throughout the lesson, and instruction is adjusted accordingly.

GUIDING QUESTIONS FOR OBSERVING MATHEMATICS LESSONS

Directions:

Before watching a lesson in mathematics, review the following questions and points—then put this guide aside. Take notes on a blank classroom observation tool or separate paper. Use your notes and these questions to guide a discussion about how certain evidence determines the presence of an indicator.

Core Action 1. Curriculum content of the lesson matches the demands of the CCR standards.	
Indicator	**Guiding Questions**
A. Instructor presents a lesson clearly reflecting CCR content standards.	• Does the lesson reflect one or more of the CCR content standards for mathematics? When possible, refer to the lesson plan for information about the target concepts and skills of the lesson. • Where in the lesson do students engage in a variety of tasks and activities reflective of the standards?
B. Instructor presents a lesson that addresses the Standards for Mathematical Practice that are central to the goals of the lesson and connected with the targeted content.	• Are any Standards for Mathematical Practice reflected in the lesson? Are they central to lesson goals? • Do lesson activities encourage students to use these or other Standards for Mathematical Practice? Note instances and examples throughout the lesson. • What “instructor moves” are used to bring out these habits of mind in students?
C. Instructor presents a lesson that matches the full depth of the requirements in the standard(s) being addressed.	• Do lesson activities address the depth of the standards being addressed? • Are some elements of the standards not being addressed? Which ones?
D. Instructor establishes well-defined standard-based lesson goals.	• Are lesson goals reflected clearly in the lesson? Note instances. • Does the instructor use the language of the standards to describe the lesson outcomes? • Throughout the lesson, does the instructor refer to lesson objectives? What does s/he say and do?

Core Action 1. Curriculum content of the lesson matches the demands of the CCR standards.	
Indicator	**Guiding Questions**
E. Instructor presents a lesson that focuses on the standards representing or supporting the Major Work of the Level (MWOTL).	• Are the target standards of this lesson identified as MWOTL? When possible, refer to the lesson plan for evidence. • If not, does the lesson support a standard that is MWOTL? Explain.
F. When addressing the MWOTL, the instructor intentionally targets one or more aspects of rigor as appropriate for the addressed standard(s).	• What of the following aspects of rigor does this lesson address? ▪ Conceptual understanding ▪ Procedural skill and fluency ▪ Application • Does the instructor ask questions throughout the lesson to check student understanding of the content? • Are students either practicing or introduced to procedural skills? If so, describe them. • Are activities presented in a real-world context? Or is the lesson introductory so that students are not yet expected to apply their learning? • After the instructor introduces the lesson content, can students apply the procedures to a different problem or context?

Core Action 2. Learning activities (questions and tasks) are challenging and maximize opportunities for students to master the lesson content.	
Indicator	**Guiding Questions**
A. High-quality, challenging questions and problems prompt students to discuss their developing thoughts about the lesson content.	• What do the activities ask students to do? • How does the instructor build challenge into the activities? • Does the instructor ask questions to promote deeper learning?
B. Students have opportunities to work with and practice level-specific problems and exercises.	• Are the activities appropriate for the level(s) of the students? • Are there a variety of problems? Do students seem engaged?
C. Instructor consistently uses explanation, modeling, or examples to make the mathematics of the lesson explicit.	• When working with students, how often does the instructor simply impart information versus ask questions, so that students will do more of the thinking and talking? • During whole-group discussions, does the instructor use explanation, modeling, or examples, or some combination of the three?
D. Instructor consistently allows appropriate wait time (3 or more seconds) after asking questions of students before prompting them for responses.	• Throughout the lesson, are students given time to express their responses and ideas? • When asking questions, does the instructor seem comfortable with wait time for responses? • After asking a question, does the instructor stay silent, or does s/he fill the space with more questions and explanations? Count the seconds waited at different times throughout the lesson.
E. Students consistently use precise mathematics in their calculations, terminology, symbols, graphs, etc.	• Does the instructor focus on using precise mathematics with students?
F. Instructor consistently asks students to elaborate on and justify their responses.	• How often does the instructor ask questions requiring elaboration or justification? Can students answer with a "yes" or "no" or a one-word answer, or must they also provide evidence and explanation? • How often does the instructor invite students to follow up on their classmates' comments? Note instances and examples in the lesson.

Core Action 3. CCR Standards are translated into lesson content that productively engages adult learners.	
Indicator	**Guiding Questions**
A. Students consistently participate actively in the lesson through class discussions and activities, group projects, etc., instead of mostly doing solitary seatwork or listening to extended lectures.	• Is the lesson dominated by instructor talk or by student talk? Estimate the minutes of each? • Is the lesson dominated by lecture or by discussion? • Are students engaged? What do you notice about the students: Do they seem bored or animated, or is it hard to tell? • Do only some, many, most, or all students actively participate in activities?
B. Students have varied opportunities to apply what they are learning in authentic or practical adult-oriented contexts.	• Are the activities practical and useful? Note instances and examples in the lesson. • Are students assigned worksheets or asked to solve authentic problems? • How can you tell that the instructor knows about the lives and interests of the students? What specific things are said to indicate that knowledge?
C. When discussing or collaborating, a vast majority of students build on each other's observations or insights (e.g., showing variation in their solution methods).	• Are there opportunities for students to collaborate? • During class discussions, does the instructor encourage students to ask each other questions or add on points?
D. A vast majority of students display persistence with tasks and problems.	• When working in groups, do students seem to give up easily on a task? • Do students appear interested in completing tasks? Do they ask questions of the instructor and their classmates to help them complete tasks?

Core Action 4. The lesson is intentionally sequenced to build on and develop students' skills and knowledge on specific concepts.	
Indicator	**Guiding Questions**
A. Instructor explicitly relates new concepts to students' knowledge.	• Does the instructor refer to previous lessons?
B. Instructor organizes lesson concepts in a way that build on their logical connections to each other.	• Does the instructor present the lesson so that the concepts build and flow smoothly? • Are there other aspects of mathematics that the instructor brings seamlessly into the lesson?
C. Instructor makes it clear how the content of the lesson supports, and is connected to, future learning.	• Does the instructor make any connections to upcoming lessons?
D. Instructor ends the lesson by reviewing lesson goals; and summarizing student learning with references to student work and discussion.	• Does the instructor close the lesson? • Does the instructor review the lesson objectives? • What does the instructor say about the next lesson?

Core Actions 5. Students' level of understanding is assessed during the lesson and instruction is adjusted accordingly.	
Indicator	**Guiding Questions**
A. Instructor consistently checks for student understanding, using informal yet deliberate methods (e.g., walks around the room to check on students' work, monitors verbal responses, assigns short problems).	• When students work individually or in groups, how does the instructor check in on their understanding? • During whole-class discussions, do you hear from many or only a handful of students?
B. Instructor consistently provides students with prompt, specific feedback to correct misunderstandings, reinforce learning, and help student revise their initial work.	• What strategies does the instructor use to correct misunderstandings or reinforce learning? Note instances and examples throughout the lesson. • When giving feedback, does the instructor use questioning to lead students to the right answers, or does s/he provide these answers to them?
C. Instructor consistently provides strategic supports and scaffolds to students who need them (e.g., individualized or peer tutoring, re-teaching, review of basic skills).	• Does the instructor provide supplemental instruction? Is it needed?
D. Instructor consistently provides extension activities for students who complete classwork early so they are not left idle or unchallenged.	• Does the instructor provide extension activities? Are they needed? • Do any students seem bored while waiting for others to finish?
E. A vast majority of students evaluate and reflect on their own learning.	• At the end of the lesson, does the instructor ask students to reflect on their learning—activating their metacognition? How so, is it effective?

COMPLETED CCR SIA CLASSROOM OBSERVATION TOOL FOR RICHMOND ONOKPITE'S LESSON

A debt of thanks is owed to the Academy of Hope Adult Public Charter School in D.C., to Mr. Richmond Onokpite, and to his students for their willingness to share their teaching and learning experiences. The video lesson showcases an example of an instructor who combines sound teaching methods with CCR-aligned content, materials, and activities, as well as students who are deeply engaged in learning important concepts in mathematics. While this video lesson shows significant strength as defined by the Core Actions of the CCR SIA Classroom Observation Tool, no lesson is expected to be perfect.

Core Action 1. Curriculum content of the lesson matches the demands of CCR standards.	Y, N, or N/A
A. Instructor presents a lesson clearly reflecting CCR content standards.	Y
B. Instructor presents a lesson that addresses the Standards for Mathematical Practice that are central to the goals of the lesson and connected with the targeted content.	Y
C. Instructor presents a lesson that matches the full depth of the requirements in the standard(s) being addressed.	Y
D. Instructor establishes well-defined standards-based lesson goals.	Y
E. Instructor presents a lesson that focuses on standards representing or supporting the Major Work of the Level (MWOTL).	Y
F. When addressing the MWOTL, the instructor intentionally targets one or more aspects of rigor as appropriate for the addressed standard(s). Mark the aspect(s) of rigor the lesson addresses: • Conceptual understanding • Procedural skill and fluency • Application	**Y • Conceptual Understanding • Procedural skill and fluency**

Evidence observed:

Indicator A:

Two CCR standards are listed in the lesson plan and reflected in the lesson. A central standard is: Understand that a function is a rule that assigns to each input exactly one output. The graph of a function is the set of ordered pairs consisting of an input and the corresponding output (8.F.1). Another is: Use a pair of perpendicular number lines, called axes, to define a coordinate system, with the intersection of the lines (the origin) arranged to coincide with the 0 on each line and a given point in the plane located by using an ordered pair of numbers, called its coordinates. Understand that the first number indicates how far to travel from the origin in the direction of one axis, and the second number indicates how far to travel in the direction of the second axis, with the convention that the names of the two axes and the coordinates correspond (e.g., x-axis and x-coordinate, y-axis and y-coordinate) (5.G.1).

Just as the standards require, Richmond addresses the concept of a function as a rule that assigns each input to exactly one output numerous times, leading to evidence of student understanding. They are also encouraged to understand and use the coordinate plane for plotting ordered pairs.

- One example of understanding the input/output definition of a function is during the warm-up. Students are asked to identify a rule and complete a table with missing inputs for corresponding outputs and vice versa.
- An example of understanding the coordinate plane is when Richmond shows students that a graph of a function is a set of ordered pairs, consisting of an input and corresponding output. While Richmond doesn't always use the language from the standard, this seems intentional. His focus is on students grasping the concepts before introducing new vocabulary terms or definitions.
- Richmond also introduces students to the concept of graphing functions [at 00:22:53:00]. He clearly communicates how to plot points, and briefly introduces the terms x-axis, y-axis, and coordinates, yet seems to intentionally steer students away from using them. This encourages students to use the "input" and "output" language rather than fall back on the often-misunderstood x and y terminology. He intentionally doesn't go into depth about some of the terms, with plans to do so in upcoming lessons.

Evidence observed: *Cont'd*

Indicator B:

Named and reflected in the lesson are: MP.8 (Look for and express regularity in repeated reasoning) and MP.3 (Construct viable arguments and critique the reasoning of others) are named and reflected in the lesson. Here are two examples of Richmond eliciting these habits of mind in students:

- MP.8—During the warm-up, students are asked to complete several function tables, helping them learn how to recognize the rule for a function based on the pattern observed in the inputs and outputs [at 00:00:25:00].
- MP.3—
  - In the small- and large-group discussions during and after the warm-up and in the graphing activity, students are asked to present and support their findings, recognize errors, and discuss the reasoning of others [at 00:05:34:00 and 00:37:49:00].
  - Richmond specifically asks students whether an answer is correct and to justify their responses [at 00:11:17:00].
  - He also asks them to critique and discuss each small group's graph [at 00:39:00:00].

Indicator C:

While the lesson doesn't present all the standards' components, this is intentional. For example, he doesn't introduce many terms defined in the standard but says he plans to so in later lessons. When he labels the axes as horizontal and vertical, and a student mentions the x- and y-axis, he says they will get to that eventually [at 00:24:35:00]. Richmond pushes students to think more deeply about the axes and what the x and y stand for rather than to just label the axes [at 0:22:55:00].

Students do understand the input/output definition of a function, can use the coordinate plane to graph points in a solution set, and create and analyze graphs.

Indicator D:

He underscores the goals listed in his lesson plan throughout the class session. For example, he reviews how they have represented a function so far (using a rule or a table) and says they will look at a third way [at 00:19:44:00]. When showing a graph later, he reinforces these three ways to show a function: with a table, a rule, and a graph [at 00:28:24:00]. He also makes a clear connection between the inputs and outputs (the ordered pairs) and the graph [at 00:26:00:00]. He points out the importance of the position of the origin of the graph [at 00:45:33:00].

Indicator E:

Both standards identified in this lesson, 8.F.1 and 5.G.1, are Major Work of the Level.

Evidence observed: *Cont'd*

Indicator F:

Two aspects of rigor are targeted in the lesson: conceptual understanding and procedural skill and fluency.

Richmond asks questions throughout the lesson to check student conceptual understanding. Here are some examples:

- After the warm-up when students report out, Richmond checks students' understanding [at 00:05:34:00].
- When introducing graphs of functions, Richmond first demonstrates with an example in front of the class, then he has students apply the concepts to another example in small groups so they can become more secure and gain conceptual understanding [at 00:22:40:00 and 00:31:34:00].
- During the graphing activity where students are working in small groups, Richmond checks on students' understanding [at 0032:49:00 and 00:34:33:00].
- When each group posts its graph at the front of the room, the class analyzes and discusses the graphs with Richmond's guidance [at 00:37:49:00].

The small group work also provides students with opportunities to build their procedural skill and fluency in creating graphs from a rule or table.

Core Action 2. Learning activities (questions and tasks) are challenging and maximize opportunities for students to master the lesson content.	Y, N, or N/A
A. High-quality, challenging questions and problems prompt students to discuss their developing thoughts about the lesson content.	Y
B. Students have opportunities to work with and practice level-specific problems and exercises.	Y
C. Instructor consistently uses explanation, modeling, or examples to make the mathematics of the lesson explicit.	Y
D. Instructor consistently allows appropriate wait time after asking questions of students before prompting them for responses.	Y
E. Students consistently use precise mathematics in their calculations, terminology, symbols, graphs, etc.	Y
F. Instructor consistently asks students to elaborate on and justify their responses.	Y

Evidence observed:

Indicator A:

The questions and problems presented are high-quality and challenging. Rarely could students answer questions posed with just a "yes" or "no." Richmond often asks probing questions to help students along in their thinking throughout the class period. Here are just a few examples:

- During the warm-up when a group of students is stuck on a problem, Richmond asks a question that moves them forward in their thinking and lets them complete the task [at 00:04:15:00].
- Richmond asks the group to explain how they got from the input to the output and someone says multiplying. Even though this answer isn't correct, he asks students to justify the answer rather than just correct it. Eventually they come up with the correct answer [at 00:06:12:00].
- One student states that the answer is decreasing and gives an amount by which it is decreasing. Someone else at another table has a different answer. Richmond writes both answers on the board and the class talks through which one is correct [at 00:08:08:00].
- Richmond has students explain their graphs and lets other students ask questions before he responds to the graph [at 00:39:19:00]. He doesn't immediately say whether the graph is right or wrong. Richmond asks several questions to pinpoint possible issues with the graphs and he invites students to follow-up on one each other's comments.

Indicator B:

The problems and activities presented are appropriate for low/middle intermediate level students. They match the standards at that level. Moreover, a variety of problems are presented. Included is a warm-up activity, an activity where students use a rule to complete a table, an activity where students graph a function, and another where students create a rule and a function table based on a graph. All students appear to be engaged in each activity—they discuss and ask questions throughout the lesson that is evidence that the problems and tasks are at the appropriate level.

Evidence observed: *Cont'd*

Indicator C:

When Richmond introduces the concept of representing functions as equations, he first uses language that students are familiar with: input, output, and rule [at 00:11:55:00]. Then, he introduces using variables instead of these terms to start to form equations. After a few examples, he has students create their own examples. He also asks many questions throughout. Moreover, when students are working in small groups or as a class, Richmond often asks questions rather than just deliver information. He often says, "I'm not telling you what I believe." In addition, each time he asks the class to comment on a graph he says, "I haven't said whether this is correct or wrong."

Indicator D:

Richmond gives students plenty of time to offer answers and ideas. He sometimes tells students that mathematicians give themselves 30 seconds to think [at 00:23:34:00]—reminding them to stop and think before answering. He often waits more than 3 seconds for an answer to a question. In addition, when students say a graph is "wrong," he gives them time to explain their thinking, even though the graph is correct [at 00:43:30:00]. Students therefore have time to reason their way to agreement about the correct answer and get the most benefit from the discussion.

Indicator E:

Richmond frequently clarifies students' answers by stating what "mathematicians" would do and say, such as using the word "point" rather than "dot" [at 00:29:11:00]. He also talks about putting students in the position of "true mathematicians" when deciding which variable will represent the input and output [at 00:14:15:00].

Other times, he intentionally avoids precise language. For example, when talking about the x-and y-axis, he refers to them as "input" and "output." As he explains in the interview, he chooses to use the terms that students know and plans to introduce other terminology in later lessons [at 00:24:49:00].

Indicator F:

Richmond frequently encourages students to elaborate on and justify their responses. During each group's presentation of its graphs, for example, he gives other students the opportunity—and encourages them—to ask probing questions, requiring groups to explain and justify their graphs [at 00:37:52:00]. Richmond guides the discussion and looks for teachable moments as he probes students' understanding.

Core Action 3. CCR standards are translated into lesson content that productively engages adult learners.	Y, N, or N/A
A. Students consistently participate actively in the lesson through class discussions and activities, group projects, etc., instead of mostly doing solitary seatwork or listening to extended lectures.	Y
B. Students have varied opportunities to apply what they are learning in authentic or practical adult-oriented contexts.	N
C. When discussing or collaborating, a vast majority of students build on each other's observations or insights (e.g., showing variation in their solution methods).	Y
D. A vast majority of students display persistence with tasks and problems.	Y

Evidence observed:

Indicator A:

The class consists overwhelmingly of class discussions and group work. Even when Richmond presents new content, he makes sure students are actively involved. For example, when introducing the concept of creating a statement or an equation based on a function rule and table, he consistently asks questions to the class and engages all students [at 00:11:50:00]. This is also true when students are reviewing the problems and activities: each group has the opportunity to present its work creating a graph. Richmond talks for roughly one-third of the class time, while students talk for the other two-thirds.

No students look bored. They all are engaged throughout the lesson and often seem to be relaxed and enjoying themselves. All students participated in the activities. Several students ask questions, and almost all students share their work and answers. Richmond calls on the quieter students at different times to bring more of them into the discussion. The combination of whole-class, small-group, and independent or partner work ensures that all students actively participate.

Indicator B:

While the class session is filled with activities (not just worksheets), no data set or function rule is presented in a real-world context. Only when a student mentions seeing a similar graph on the GED test does Richmond connect the concept to a practical experience [at 00:30:55:00].

Since students are only learning the basics of graphing, however, it's not unreasonable to wait until future lessons to ask them to apply their knowledge to a real world or practical problem. The lesson plan mentions that such a problem will be covered in the next lesson, but Richmond does not say so explicitly during his lesson preview.

Indicator C:

Richmond does well in facilitating the discussion so that students build on each other's observations and insights. During the discussion on graphs, Richmond has each group present its graph and then encourages other students to ask questions [at 00:37:52:00]. Richmond has obviously created an atmosphere of safety and trust in the classroom. Students freely share their thinking and are respected by both Richmond and their classmates, even when they make a mistake. Throughout the lesson, discussions are open and collaborative.

Evidence observed: *Cont'd*

Indicator D:

When students work with the activities and problems, they are engaged, persistent, and supportive of each other's learning. Richmond also circulates [at 00:02:22:00] and asks questions to help move students along in their thinking, so that they don't get stuck on one concept or idea. During class discussions, students often ask thoughtful questions that show their engagement [at 00:08:52:00], and the small group presentations of graphs ensures full student participation [at 00:37:42:00].

Core Action 4. The lesson is intentionally sequenced to build on and develop students' skills and knowledge of specific concepts.	Y, N, or N/A
A. Instructor explicitly relates new concepts to students' knowledge.	Y
B. Instructor organizes lesson concepts in a way that builds on their logical connections to each other.	Y
C. Instructor makes it clear how the content of the lesson supports, and is connected to, future learning.	Y
D. Instructor ends the lesson by: • Reviewing lesson goals; and • Summarizing student learning with references to student work and discussion.	Y

Evidence observed:

Indicator A:

Richmond begins with a warm-up to clarify students' understanding of functions [at 00:00:25:00]. He reviews the definition of a function by having students identify a rule based on the first few entries of a table and then has them complete the table. He also reiterates the meaning of terms like "rule," "input," and "output," which are key terms to writing statements or equations to represent functions [at 00:05:32:00].

Indicator B:

The lesson focuses on the three views of a function: a rule, table, and graph. The concepts build and flow smoothly. Richmond first reviews student understanding of finding a table of solutions based on the rule [at 00:00:25:00] and then moves on to creating a graph [at 00:22:41:00]. He then gives students a graph and has them create a rule and a table [at 01:01:46:00]. By the end of the lesson, when students are given a rule, table, or graph, most of them can create the other two views of that function. He also uses the calculation of the inputs and outputs to incorporate a conversation on decimals and fractions [at 00:07:32:00].

Indicator C:

Periodically, Richmond makes connections to upcoming lessons. For example, he talks about looking at different types of equations (nonlinear) in upcoming lessons [at 00:18:10:00]. He also explains that they will be looking at different types of graphs in the coming weeks [at 00:30:31:00].

Indicator D:

At the end of the lesson, Richmond previews the next class [at 1:10:31:00]. Earlier on, he also reviews student learning about the three views of functions: an input/output table, rule, and graph [at 00:28:21:00]. While he doesn't summarize student learning at the end of the lesson, he does so at different points throughout, such as on graphing functions [at 00:59:41:00].

Core Action 5. Students' levels of understanding are assessed throughout the lesson, and instruction is adjusted accordingly.	Y, N, or N/A
A. Instructor consistently checks for student understanding, using informal yet deliberate methods (e.g., walks around the room to check on students' work, monitors verbal responses, assigns short problems).	Y
B. Instructor consistently provides students with prompt, specific feedback to correct misunderstandings, reinforce learning, and help students revise their initial work.	Y
C. Instructor consistently provides strategic supports and scaffolds to students who need them (e.g., individualized or peer tutoring, re-teaching, review of basic skills).	Y
D. Instructor consistently provides extension activities for students who complete classwork early so they are not left idle or unchallenged.	N/A
E. A vast majority of students evaluate and reflect on their own learning.	N

Evidence observed:

Indicator A:

Richmond checks for student understanding in numerous ways: Anytime students work in groups, Richmond circulates, checks their work, and asks questions to confirm understanding. After students complete the graphing activity, each group presents its work, allowing Richmond to gauge everyone's understanding of the content. Richmond stands back and looks then asks, "How did we get different graphs?" [at 00:38:07:00]. Students then offer theories. This lets Richmond continue to ask questions until the class realizes that different scales change the look but not the substance of a graph. He also calls on different students during whole class discussions. When students are confused about how to determine an output from a table, Richmond repeats the question, rather than simply correcting the wrong answer. He also waits for students to respond or ask questions themselves [at 00:25:47:00].

Indicator B:

Richmond provides specific feedback to students throughout the lesson to correct misunderstandings. For example, when a group misunderstands the origin on a graph—writing a zero on both the x- and y-axis—Richmond says doing so is mathematically incorrect [at 00:52:04:00]. He gives a practical example to help students understand its location at (0, 0)—although he never uses the word "origin." He also asks one group to save its incorrect graph, mistakes and all, to provide a "teachable moment" for all students about common misconceptions [at 00:47:07:00].

Indicator C:

Richmond responds to a student's confusion during class discussion by taking time to review the concepts until she understands [at 00:55:23:00]. Then, while the class is working, he works one-on-one with another student at the board on a graphing question until the student also understands [at 01:07:40:00]. He also tells two students he "is not done with them yet" as he closes out the lesson [at 01:38:00:00].

Evidence observed: *Cont'd*

Indicator D:

Because students don't complete the classwork early, extension activities are not needed.

Indicator E:

Richmond does not specifically ask students to reflect on their learning. Several students do carefully take notes, but it is not clear whether they are reflecting on their learning or just taking contemporaneous notes [at 00:00:25:38].

LESSON PLAN FOR MATHEMATICS

Created by Richmond Onokpite • Academy of Hope Adult Public Charter School • District of Columbia

1 **Title of the lesson:**

The Three Views of a Function: Rule, Table, and Graph

2 **Intended instructional level of the lesson:**

Low/Middle Intermediate Level

3 **Brief description of how the lesson is to be used:**

After being introduced to the concept of function using a function machine, students will expand their knowledge by graphing functions. Students will work with three ways to represent a function:

1. A rule—a verbal description or equation,
2. A table—two columns showing the corresponding "inputs" and "outputs,", and
3. A graph—with horizontal and vertical axes to represent the inputs and outputs, respectively.

4 **Learning goals of the lesson:**

Students will be able to:

1. Given a rule, the table, or a graph of a function, create the other two views of a function.
2. Identify whether an input/output pair is a solution for a given function.
3. Create data tables and interpret information from a table.
4. Graph in one quadrant using the traditional x-y grid.

5 **Suggested time to spend on the lesson (e.g., number of learning sessions, hours/minutes):**

One 90-minute session

6 **The college and career readiness standards addressing the major work of the level (MWOTL) targeted by this lesson:**

- Understand that a function is a rule that assigns to each input exactly one output. The graph of a function is the set of ordered pairs consisting of an input and the corresponding output. (8.F.1)
  MWOTL (Middle Intermediate): Functions – Developing the concept of function and graphing functions in the coordinate plane and analyzing their graphs.

- Use a pair of perpendicular number lines, called axes, to define a coordinate system, with the intersection of the lines (the origin) arranged to coincide with the 0 on each line and a given point in the plane located by using an ordered pair of numbers, called its coordinates. Understand that the first number indicates how far to travel from the origin in the direction of one axis, and the second number indicates how far to travel in the direction of the second axis, with the convention that the names of the two axes and the coordinates correspond (e.g., x-axis and x-coordinate, y-axis and y-coordinate). (5.G.1) MWOTL (Low Intermediate): Geometry – Developing understanding of the coordinate plane.

7 **The Standards for Mathematical Practice that are central to the goals of the lesson and their connections to the content of the lesson:**

Primarily:

MP 8. Look for and express regularity in repeated reasoning.
In this lesson, students are asked to complete several function tables and create the function graph. In doing so, they learn how to recognize the rule for a function, based on the pattern they observe in the inputs and their corresponding outputs.

Secondarily:

MP 3. Construct viable arguments and critique the reasoning of others.
In the group discussion after both the "group walk" activity and the graphing activity, students are asked to present and support their findings, recognize errors, and discuss the reasoning of others.

8 **Prerequisite or foundational content students need to succeed in the lesson:**

- To apply the function rule and create a table of values, students need to be fluent in basic operations involving whole numbers and decimals.
- Students need an informal understanding of the concept of function.

9 **Description of how the content of the lesson is related to other content taught at the lesson's level:**

Previously, students reviewed bar graphs, line graphs, circle graphs, and pictographs. They should be familiar with the horizontal and vertical axes and line graphs and know how to apply that knowledge in creating the graph of a function.

In the preceding lesson, students were introduced to the concept of function using a function machine. Students used a one-operation rule to complete a table of values and identified a one-operation rule that corresponds with a table of values.

After completing the current lesson, students will move on to completing a table of values when given a two-operation function rule. They will also identify a two-operation function rule when given a table of values or a graph. This leads to using functions to represent and solve practical problems.

10 **Notes for implementing the lesson:**

The suggested lesson sequence is as follows.

Engage: Gallery walk [Timestamp: 00:00:20:00]

Students should work in pairs to answer the questions on the charts posted at the "group walk" stations (at tables) titled, "What Is My Rule?"; "What Is My Output?"; and "What Is My Input?" This will provide students with several opportunities to describe the rule.

Bring the whole group together to discuss the various answers given by the students and to provide students with the opportunity to defend their answers. Students need to be comfortable with finding the function rule and presenting it verbally—before being introduced to the symbolic representation (equation).

Explain: Introduction to the three views of function [Timestamp: 00:10:16:00]

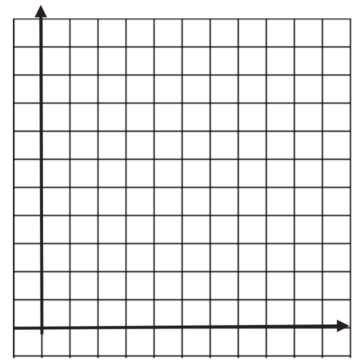
Find a rule and its equation. Once students discover the rule for a set of ordered pairs, ask them to write the "equation" in words: input … rule = output. For example, if the rule is +2, it is: input + 2 = output. Then offer them the option of replacing the words "input" and "output" with letters (variables). In this example, the new equation is a + 2 = b. Make sure each table group has a chance to write an equation and use rules that involve multiplication. For example, if the rule is x6, it is: input x 6 = output. Here, students need to know that by convention it is most appropriate to put numbers before letters for multiplication: 6a = b is more conventional than a x 6 = b or a6 = b.

Build a table. Write numbers 1 through 5 in the input column of the table. Write in "+2" as the rule, and ask the students to complete the outputs.

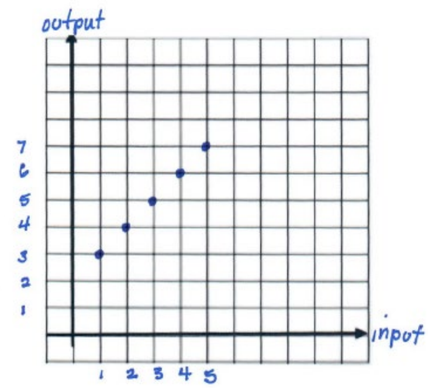
Make a graph. Tell the students that a graph is used to show the values of the inputs and outputs for a function. It is sometimes used instead of a table, or in addition to it. Go through one example of plotting points on a graph for the class. To do this, create a large version of the example graph on the board or on large graph paper that can be attached to the board, or project a version of the graph onto a screen.

Using the horizontal axis for the inputs and the vertical axis for the outputs, plot the input of 1 and the output of 3 on the graph. Explain the process to the students, and then call out different students to plot the other input/output pairs.

Rule + 2		
In	Out	
1	3	(1, 3)
2		
3		
4		
5	21	



Use the word "coordinates" instead of "input/output pairs" or "points." Coordinates come from the input/output in the table and must be written as pairs. Write the first ordered pair in the third column of the function table and have students call out the remaining input/output pairs. At this point, students should say what they notice about the graph and whether or not they can connect all the points. This is also a good occasion to ask students if it is possible for the graph to be a zigzag (nonlinear) instead of a straight line (linear).



[Solution: Ordered pairs – (1, 3), (2, 4), (3, 5), (4, 6), (5, 7) Graph – see right]

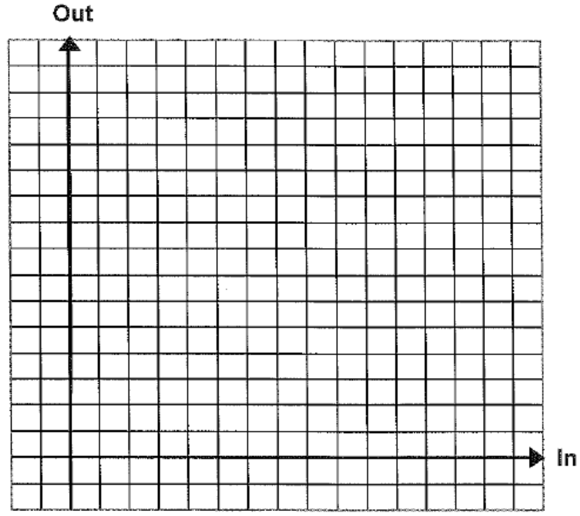
Explore: Graph Functions [Timestamp: 00:31:20:00]

Make sure the students are comfortable with the procedure before giving them a new rule from which they will create a table and then a graph.

- Have students work in pairs or small groups to complete the function tables below (Questions 1 and 2). They should use the rule provided and then create the corresponding graphs by plotting the ordered pairs (input, output) from their tables. Point out that these tables start with 0, rather than 1. Make sure students have a clear understanding of (0, 0) as a position on the coordinate plane (the intersection of the two axes).
- Move around the room to observe students' graphs and provide necessary guidance and feedback.
- Once students have completed the activity, each group should present its graph to the class. The other students in the class should be given the opportunity to ask questions and critique the graphs. There may be differences in the way the graphs look, based on how students selected and spaced the units for the two axes. This is a good time to discuss the importance of using a uniform scale in creating a graph. [NOTE: In the graphs shown below, the units are not identified. Students should be reminded to identify the scale before they plot any points.]

QUESTION 1

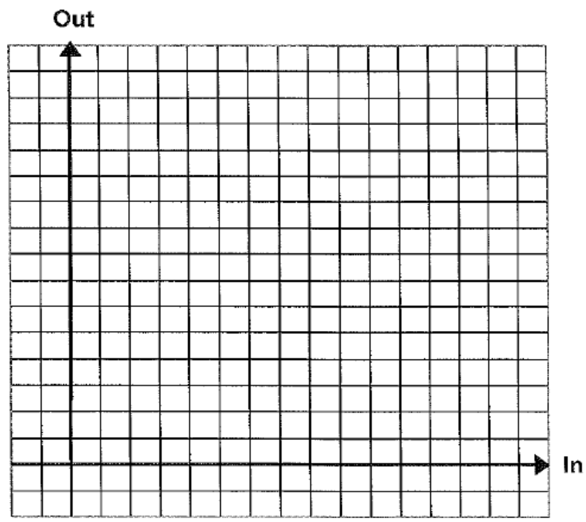
Rule: + 3		
In	Out	Solution
0		
1		
2		
3		
4		
5		
6		
7		



[Solution: Ordered pairs – (0, 3), (1, 4), (2, 5), (3, 6), (4, 7), (5, 8), (6, 9), (7, 10)]

QUESTION 2

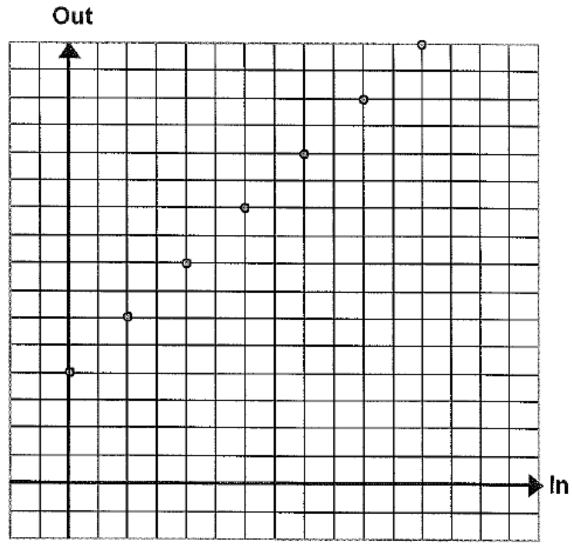
Rule: x 2		
In	Out	Solution
0		
1		
2		
3		
4		
5		
6		
7		



[Solution: Ordered pairs – (0, 0), (1, 2), (2, 4), (3, 6), (4, 8), (5, 10), (6, 12), (7, 14)]

Extend: Working to Create a Function Table From a Graph [Timestamp: 00:59:55:00] Once students can complete the function tables and draw the graphs with little or no teacher assistance, begin the next activity: Present a blank function table along with a graph that identifies the points as dots only. Students should work in pairs or small groups to come up with the function table and determine the rule. Once students have completed the activity, each group should explain and defend its findings to the class.

Rule:		
In	Out	Solution



[NOTE: In this example, the units are not identified, so the assumption is that each mark represents one unit.]

[Solution: Ordered pairs – (0, 4), (2, 6), (4, 8), (6, 10), (8, 12), (10, 14), (12, 16)
Equation – output = input + 4, or b = a + 4]

The “application” component of rigor, which gives students an opportunity to think deeply about math and solve real-life problems, will be covered in the next lesson.