

Balanced Assessment in Mathematics: Professional Development Series

Mathematics Assessment Resource Service, Michigan State University

Summary

This tool is designed to support leaders to broaden and deepen *teachers'* understanding of the role of assessment in supporting improved teaching and learning and to broaden conceptions of the role that *teacher leaders* might play in supporting colleagues as they work together to implement standards-based reform.

Purpose

To provide a component of professional development that will enhance teachers' capacity to use assessment to monitor student learning and adjust their own teaching.

Tool Description

This tool is a collection of Leader Guides that fully support 8 or more 3-hour workshop sessions. The Guides feature rich mathematical tasks, student work, and classroom video recordings. The series is designed around three themes: *Understanding Student Understanding*; *Using Assessment to Support Teaching and Learning*; and *Scoring What We Value*. It builds on a practice of professional development that focuses on teacher learning and shifts the curriculum and discourse of professional development away from simply giving teachers things to do in their classroom toward providing support for more reflective approaches to assessment and instruction. The curriculum is designed to enhance teachers' capacity to use assessment to monitor student learning and adjust their own teaching.

Tool Materials

This tool is composed of the following materials:

1. **Introduction to the Series.** An overview of all the sessions, and rationale for the design and organization of the series.
2. **Concept Map Activity.** An introductory, "ice-breaker" activity focused on participants getting to know each other through work on assessment
3. ***Understanding Student Understanding: session protocol.*** Describes the general routine used with this type of session. The Protocol includes blackline masters of discussion questions used for all *Understanding Student Understanding* sessions, regardless of the task. The Protocol allows for customization so that any performance task and locally collected student work can be used. Specifically, this type of session has teachers:
 - grapple with the core elements of mathematical performance in the task;
 - experience and come to appreciate the variety of ways in which one can reason about and approach the task;
 - carefully analyze students' responses for evidence of what they understand and where they are struggling; and
 - consider what the teacher might do next to help students where they need more work.
4. ***Understanding Student Understanding: collection of task-specific leader notes.*** Each contains a blank copy of the task, carefully selected student work on the

task, and detailed commentary. The following is a brief description of the task collection.

Algebra

- **Addworm**—patterns and functions in geometric context; using simple functions to answer questions, complete a chart, and reverse rules; several variants suitable for grades 1-5.
- **Arranging Desks**—patterns and functions in a geometric context; finding and extending a pattern and solving a problem; representing data; suitable for elementary grades.
- **Banquet Tables**—patterns and functions in a geometric context; finding and extending a pattern and solving a problem; suitable for middle grades.
- **Bead Bracelets**—number and patterns; extending and creating patterns; suitable for use in lower elementary grades.
- **Fractions of a Square**—number; use spatial and numerical reasoning about fractions as parts of a whole; includes transcript of group of students working together on the task; suitable for grades 4-6.
- **Supermarket Carts**—structural analysis; formulating an approach and solving a problem; suitable for high school.
- **Toothpicks**—patterns and functions in a geometric context; formulate relationships through generalizing patterns; suitable for middle grades.

Data Analysis and Probability

- **Beach Day**—handling data; interpret a chart and justify recommendation; suitable for lower elementary grades.
- **Field Trip**—handling data and number; combine survey data given in three forms; graph and interpret data; compute the cost per student; report recommendations; suitable for elementary to early middle grades.

Geometry and Measurement

- **Grass for Goats**—geometry; area properties of circles; comparisons; suitable for middle grades.
- **Identifying Triangles**—geometry; identifying triangles and non-triangles; suitable for use with lower elementary grades.
- **Old Ruins**—geometry; use symmetry to complete designs; use properties of shapes to describe designs; suitable for elementary grades.

Number and Operations

- **Buying Art Supplies**—number and quantity; interpret and use a pictograph to apportion resources; use unit costs to calculate totals; suitable for use with upper elementary grades.
 - **Consecutive Addends**—patterns and generalizations in a number context; suitable for use with middle grades to high school.
 - **Fruit Stand**—number; transform number sentences to word sentences; suitable for use with lower elementary grades.
 - **Share the Fare**—proportional reasoning; suitable for middle grades.
5. **Using Assessment to Support Teaching and Learning: collection of leader notes.** The aim of this kind of session is to provide examples of teachers using high-quality assessment tasks to support student learning:
- **Magic Age Rings** is a video case of a third grade teacher using a task for informal assessment and then following up with a whole class discussion about

how students reasoned about the situation. The case includes interviews with the teacher before the class (to provide some context for viewing the video) and after the class (about what surprised her and where she thinks her students need more work).

- *T-shirt Design* is built around a 7th grade teacher's use of a task in which students get peer feedback on their initial response to a task. They then use that feedback to revise their response.
 - *Camp Placement* is a video case of a middle grades teacher using a task for informal assessment. The case highlights the launch, a pair of students working together on the task, and the whole class discussion that followed.
 - *Designing a Tent* is an open-ended formulation task that involves using estimates of the size of a typical adult to design a tent.
 - *Test Prep Tool* is designed to support teachers who want to prepare students for high stakes assessment on typical multiple choice tasks in ways that are educative, that reveal misconceptions and faulty reasoning, and that promote further learning. This strategy goes beyond just giving students new tasks. A key to turning test prep into learning is to engage students in conversations about how they reasoned about an item, and to consider what kind of reasoning would lead to the selection of the right and of the wrong answers. This kind of discussion can help students to come to understand their own misconceptions, mistakes, and faulty reasoning, and thus foster new learning.
6. **Scoring What We Value Collection of Leader Notes.** It is in scoring that we make explicit what we value in mathematical performance. Over three sessions at the end of the series, teachers consider different methods of scoring student work and the purposes that distinct kinds of rubrics might serve. Together, the activities are designed to help teachers consider how, when, and to what ends various scoring rubrics might be used:
- *Developing a Task Specific Holistic Rubric* gives teachers a different kind of experience in the role of analyzing, interpreting, and scoring student responses to performance assessment tasks. The outcome of the process is a set of qualitative descriptions characterizing four levels of student performance on a specific task. Teachers find the process of sorting student work that precedes developing the rubrics a useful way of looking at student work in their own classrooms, even if not applying holistic rubrics. What they learn by examining papers in the sorting process can guide them in thinking about where to go next in instruction.
 - *Using Rubrics to Give Feedback: Scoring What We Value* raises issues about the kinds of feedback teachers give to students and to consider the role that rubrics can play in this regard. They consider the nature of the feedback and what students might do with it. Then, they examine and apply several different rubrics—holistic, holistic-by-category, and point—to each student response. The discussion turns to the various kinds of rubrics, what purposes different types of rubrics might serve, and how different rubrics reflect what is valued in a response.
 - *Using General Rubrics to Guide Student Responses* has teachers develop a generic rubric intended to provide guidance to students about writing thoughtful, strong, complete and clear responses to any constructed-response task. The work begins by examining examples of generic rubrics, looking for similarities and differences in what is valued in performance and what is communicated to students. Teachers, in small grade-level groups, develop

their own generic rubric for use in their own classrooms. There is no interest here in reaching any level of consensus on a generic rubric. Rather, through discussion, each teacher creates a tool whose purpose is to help her/his own students work toward writing responses that provide evidence of what they know and what they can do.

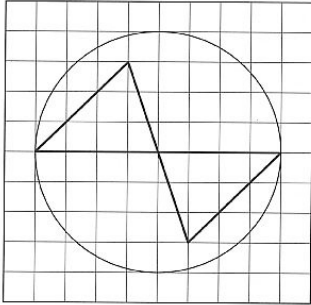
Exemplar

Below is an example of one task from the collection, *T-shirt Design*, with student work and a description of how it can be used across all three themes.

Name _____ Date _____

T-shirt Design

The design below, including the 10-by-10 grid, is going to be used on a math team T-shirt. You accidentally took the original design home, and your friend Chris needs it tonight. Chris has no fax machine, but he does have a 10-by-10 grid just like yours (see Chris's grid on the next page). You must call Chris on the telephone and tell him very precisely how to draw the design on his grid.



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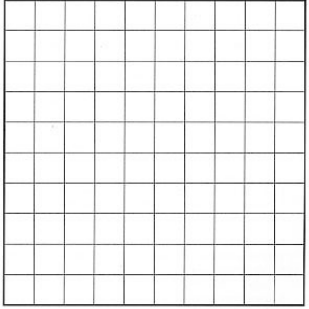
Name _____ Date _____

This problem gives you the chance to

- systematically communicate about geometric shapes
- locate shapes on a grid
- give a clear set of directions

On your own

This is the grid that Chris has in front of him. Prepare for your phone call by writing out your directions. Once you have finished, check your work to make sure that Chris will be able to recreate the design from your description.



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Understanding Student Understanding

Teachers write their own directions to the *T-shirt Design* task, share them with others as the facilitator focuses the conversation on the variety of systems teachers have for specifying the directions. The following discussion questions are taken up:

- What are the “core elements of performance”?
- What does the task have the potential to reveal about students’ understanding of content, problem solving and reasoning, and communication?
- Why would a teacher use a task like this?
- Where would this task appropriately fit in your curriculum?

Then teachers examine samples of student’s directions that are provided in the materials, using the following questions to guide their analysis:

- What does the student seem to understand and what is the evidence?
- What does the student seem to be struggling with? What does she seem to be confused about? Where does he show partial knowledge? What is the evidence?
- What logic might lead a student to respond incorrectly?

The design below, including the 10-by-10 grid, is going to be used on a math team T-shirt. You accidentally took the original design home, and your friend Chris needs it tonight. Chris has no fax machine, but he does have a 10-by-10 grid just like yours (see Chris' grid on the next page). You must call Chris on the telephone and tell him very precisely how to draw the design on his grid.

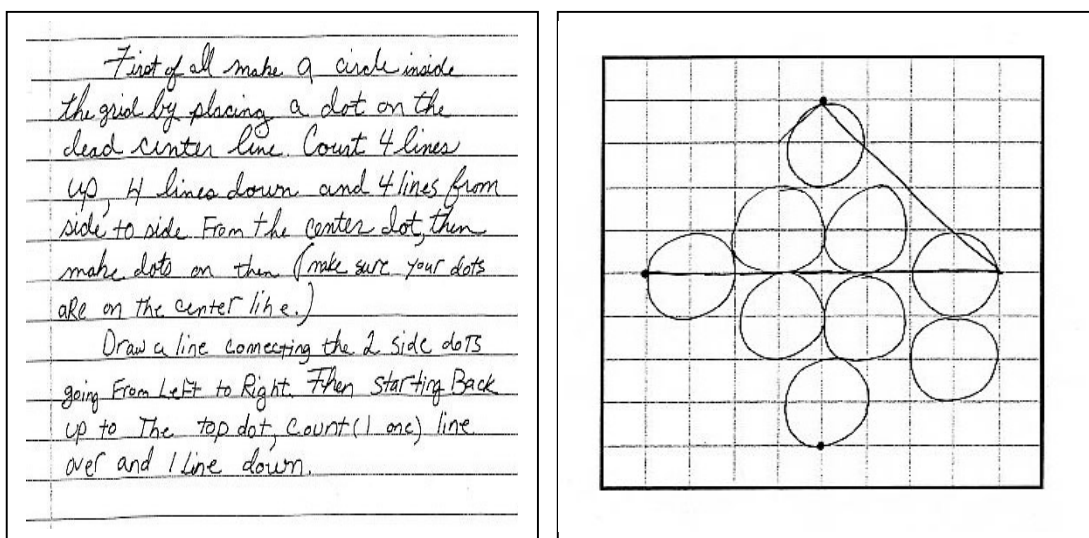
1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50
51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70
71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90
91	92	93	94	95	96	97	98	99	100

Sasha's work

1. Number them 1 to 100 starting from the top left-hand corner
2. At the line separating 42 from 52 make a 4-inch line going from boxes 42 and 52 across to 49 and 59
3. Make a quarter of a circle starting at the left edge of the middle line going to the center of 5, 6, 15, and 16.
4. Make another quarter of a circle starting at the center of 3, 6, 15, and 16 and ending at the center of 49, 50, 59, and 60.
5. Make another quarter of a circle starting at the center of 49, 50, 59, and 60 and ending at the center of 85, 86, 95, and 96.
6. Make another quarter of a circle start at the center of 85, 86, 95, and 96 and ending at the center of 41, 42, 51, and 52 which is where you started. You should now have a circle that is 4-inches wide and 4-inches tall. If you have have a line from the top of the circle to the bottom of the circle erase it.
7. Make a line from the center of boxes 14, 15, 24, and 25 to the center of boxes 76, 77, 86, and 87.
8. Now make a line going from the centers of the boxes 76, 77, 86 and 87. to the right-hand end of the line that you made in the beginning
9. Make a line connecting the the line that begins at the center of 14, 15, 24, 25 to the left-hand end of the line you made in the beginning.

Using Assessment to Support Teaching and Learning

One of the Leader Notes describes a way in which a teacher used T-shirt Design in her middle grades class. She gave students in one class the task of writing a set of directions. She then gave the written directions to a second class of students who had not seen the design. She instructed them to make a design by following carefully the set of written directions. The next day she returned the directions and the drawing made from them to the student who had written the directions. They were instructed to revise their directions based on the drawing. Then she gave the revised directions to a third class unfamiliar with the design and instructed them to make the design. Finally she returned the second set of drawings to the direction writer. Below is the set of work that resulted from Aaron's efforts and a set of questions to guide the discussion.



Aaron's original narrative, and a student's attempt to follow the directions

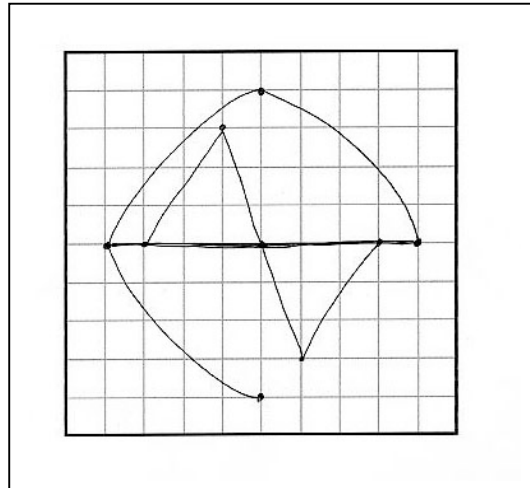
- How do you see assessment and learning both taking place?
- In what ways might you have students use peer feedback on responses to other types of performance tasks?
- How and what might students learn in the process?

First make a dot on the middle of the center line. From the center dot, count 4 lines up and make a dot. Then from the dot you just made, go down 3 lines and make a dot. Do the same for the sides starting from the center dot.

Then after you have made all of your dots, connect the 4 dots you made by using the ~~center~~ center dot with 1 (one) big circle.

Now you should have only 1 (one) circle on your grid with one dot in the center or the center line. Next from the center ~~line~~ line make a line going across ~~the~~ over the dot. From the center ~~dot~~ dot, count over to the right 1 line go down 3 lines then ~~make~~ make a dot on the line.

From the center dot 3 lines go 1 line to the left and make dots ~~you~~ you just made with a straight line. By now you should have a circle with a line going across in the center and ~~another~~ another line crossing the center line another slanted line crossing the center one. Now connect each 2 ends of the lines with a straight line. Now you should have a symbol that looks like a time glass tipped.



Aaron's revised narrative, and a different student's attempt to follow the revised directions

Scoring What We Value

Sasha's work can also be used to apply various rubrics to get a sense of what different rubrics communicate about what is valued in performance.

T-shirt Design **Holistic Rubric**

The characterization of student responses for this task is based on these 'Core Elements of Performance':

- locate the placement of all parts of the design (circle, diameter, zigzag) on a grid
- use an economic and systematic approach (may be an invented system)
- give a clear set of directions

Level 4: The student's work meets the essential demands of the task

Student gives a complete, economic system that is capable of locating all parts of the design with reasonable accuracy AND directions are clearly stated and easy to follow.

Level 3: The student's work needs to be revised

Student gives a system that addresses all parts of the design, which has the potential for locating points precisely but the system is not economic, resulting in inaccuracies. Some effort may be needed to follow the directions.

Level 2: The student needs some instruction

Student attempts a system for locating all parts of the design but the system does not have the potential for locating points precisely, resulting in errors in placement or a lack of relationship between the whole design and its parts OR considerable effort is needed to follow the directions.

Level 1: The student needs significant instruction

Student uses no system for locating parts of the design and makes major errors in placement or distorts the shape of design.

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T-shirt Design **Holistic by Category Rubric**

Geometry, Space and Shape

Level 4 Student describes specific parts of the geometric figures clearly and for the most part is successful in relating the placement of the figures to the grid.

Level 3 Student describes specific parts of the geometric figures clearly and attempts, although unsuccessfully, to relate the figures to placement on the grid.

Level 2 Student describes the geometric figures (with non-standard language OK), and attempts, although unsuccessfully, to relate the figures to placement on the grid.

Level 1 Student describes the geometric figures (with non-standard language OK), but does not address location within the grid.

Level 0 Student did not engage; unscorable; irrelevant response.

Problem Solving and Reasoning

Level 4 The student gives a complete, economic system that has the potential to place all points precisely.

Level 3 The student gives a system that addresses all parts of the design, and it has potential for placing the points accurately, but the system is not economic, or may result in some inaccuracies.

Level 2 Student attempts to use a system for locating the parts of the design, but the system does not have the potential for placing points precisely.

Level 1 Student uses no apparent system for precisely locating parts of the design.

Level 0 Student did not engage; unscorable; irrelevant response.

Communication

Level 4 The student provides "checks" for the listener to test whether the figure drawn matches the intended figure.

Level 3 The student's instructions are clear and ordered in a step-by-step fashion.

somehow clear, somewhat clear, directions, but is unclear, unscorable; irrelevant response.

T-shirt Design Point by Category Rubric 15 points

Step	GSS	PSR	C
A systematic approach • Uses an effective system for locating components of the figure <i>Partial credit:</i> some evidence of a system with potential, but results in inaccuracies or errors • System is economic		2 (1) 1	
The circle • Locates circle on the grid accurately <i>Partial credit:</i> mentions the circle	2 (1)		
The diameter • Locates on the grid or circle <i>Partial credit:</i> mentions or implies the diameter	2 (1)		
The zigzag • Locates 4 endpoints of the segments of the zigzag Allow 1 point for each correct endpoint	4 x 1		
Clarity of instructions • Instructions are ordered • Instructions are clear <i>Partial credit:</i> instructions are partially clear but have essential information missing • Instructions include checks for listener			1 2 (1) 1
Points allocated	8	3	4

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The following issues emerge in applying the various rubrics:

- When using a holistic rubric, how do I decide how much weight to give to the several aspects of performance that are included in a single level?
- What might the holistic-by-category rubric suggest to students about what is valued in mathematical performance?
- How might the use of rubrics provide useful feedback to students and what might I expect them to do with this feedback?

Using the Tool

This tool assumes the leader has some experience with facilitating professional development for teachers of mathematics, as well as some experience with standards-based assessment.

Evaluative evidence: These materials have received high marks from leaders who find them user-friendly and flexible in their use, allowing adaptation and customization to respond to local circumstances.

What leaders have said about Balanced Assessment in Mathematics professional development materials:

"As is your custom—The highest quality."

"I learned so much about assessment and will take this knowledge home to use in my classroom and share with the teachers in my district. Thank you for all the beautiful overheads."

"Exceptional materials. This will be a valuable part of my professional toolkit."

Strengths

These materials can be used to help teachers prepare their students for performance assessment tasks and assess the quality of student work, since the tasks focus on the much wider range of types of tasks, and thus of performance that new standards require. The series can also be used as a powerful stimulus for broader development of capacity to carry out reform. And the series can be a site for helping teachers deepen and broaden their own mathematical knowledge.

Availability

These materials were developed by the Balanced Assessment for the Mathematics Curriculum Project and its successor, the Mathematics Assessment Resource Service (MARS), through a grant from the National Science Foundation. A CD with a complete set of all the materials described above is available at no cost from

MARS

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