

## Section 3: Resources, References, and Glossary

### Resources

| Evidence-Based Resources   | English Learner Resources  | MLSS Resources   | Mathematics Standard Resources   |
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| <a href="#">What Works Clearinghouse</a><br><br><a href="#">Best Evidence Encyclopedia</a><br><br><a href="#">Evidence for Every Student Succeeds Act</a><br><br><a href="#">Evidence in Education Lab</a> | <a href="#">World-Class Instructional Design and Assessment (WIDA) Standards</a><br><br><a href="#">USCALE Language Routines for Mathematics</a><br><br><a href="#">English Language Development Standards</a><br><br><a href="#">Spanish Language Development Standards</a> | <a href="#">NM Multi-Layered System of Supports (MLSS)</a><br><br><a href="#">Universal Design for Learning Guidelines</a><br><br><a href="#">Achieve the Core: Instructional Routines for Mathematics</a><br><br><a href="#">Project Zero Thinking Routines</a> | <a href="#">Focus by Grade Level and Widely Applicable Prerequisites High school</a><br><br><a href="#">Coherence Map</a><br><br><a href="#">College-and Career Ready Math Shifts</a><br><br><a href="#">Fostering Math Practices: Routines for the Mathematical Practices</a> |

### Planning Guidance for Multi-Layered Systems of Support: Core Instruction<sup>9</sup>

Core Instructional Planning must reflect and leverage scientific insights into how humans learn in order to ensure all students are ready for success, thus the following guidance for optimizing teaching and learning is grounded in the [Universal Design Learning \(UDL\) Framework](#)

Key design questions, planning actions, and potential strategies are provided below, with respect to guidance for minimizing barriers to learning and optimizing (1) universal ACCESS to learning experiences, (2) opportunities for students to BUILD their understanding of the [Learning Goal](#), and (3) INTERNALIZATION of the Learning Goal.

| Optimizing Universal ACCESS to Learning Experiences   |   |
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| <p><b>ENGAGEMENT</b></p> <p><input type="checkbox"/> How will you provide multiple options for recruiting interest?</p> | <p><b><a href="#">Recruiting Student Interest:</a></b></p> <p><input type="checkbox"/> What do you anticipate in the range of student interest for this lesson?</p> <p><input type="checkbox"/> Plan for options for recruiting student interest:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> provide choice (e.g. sequence or timing of task completion)</li> <li><input type="checkbox"/> set personal academic goals</li> <li><input type="checkbox"/> provide contextualized examples connected to their lives</li> <li><input type="checkbox"/> support culturally relevant connections (i.e home culture)</li> <li><input type="checkbox"/> create socially relevant tasks</li> <li><input type="checkbox"/> provide novel &amp; relevant problems to make sense of complex ideas in creative ways</li> </ul> |

<sup>9</sup> Adapted from: CAST (2018). *Universal Design for Learning Guidelines version 2.2*. Retrieved from <http://udlguidelines.cast.org>

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|   | <ul style="list-style-type: none"> <li><input type="checkbox"/> provide time for self-reflection about content &amp; activities</li> <li><input type="checkbox"/> create accepting and supportive classroom climate</li> <li><input type="checkbox"/> utilize <b>instructional routines</b> to involve all students</li> </ul>  |
| <p><b>REPRESENTATION</b></p> <p><input type="checkbox"/> How will you reduce barriers to perceiving the information presented in this lesson?</p>                       | <p><b>Perception:</b></p> <p><input type="checkbox"/> What do you anticipate about the range in how students will perceive information presented in this lesson?</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Plan for different modalities and formats to reduce barriers to learning:             <ul style="list-style-type: none"> <li><input type="checkbox"/> display information in a flexible format to vary perceptual features</li> <li><input type="checkbox"/> offer alternatives for auditory information</li> <li><input type="checkbox"/> offer alternatives for visual information</li> </ul> </li> </ul>  |
| <p><b>ACTION &amp; EXPRESSION</b></p> <p><input type="checkbox"/> How will the learning for students provide a variety of methods for navigation to support access?</p> | <p><b>Physical Action:</b></p> <p><input type="checkbox"/> What do you anticipate about the range in how students will physically navigate and respond to the learning experience?</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Plan a variety of methods for response and navigation of learning experiences by offering alternatives to:             <ul style="list-style-type: none"> <li><input type="checkbox"/> requirements for rate, timing, speed, and range of motor action with instructional materials, manipulatives, and technologies</li> <li><input type="checkbox"/> physically indicating selections</li> <li><input type="checkbox"/> interacting with materials by hand, voice, keyboard, etc.</li> </ul> </li> </ul> |

| <h2 style="text-align: center;">Opportunities for Students to BUILD their Understanding</h2>   |  |
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| <p><b>ENGAGEMENT</b></p> <p><input type="checkbox"/> How will the learning for students provide options for sustaining effort and persistence?</p> | <p><b>Sustaining Effort &amp; Persistence:</b></p> <p><input type="checkbox"/> What do you anticipate about the range in student effort?</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Plan multiple methods for attending to student attention and affect by:             <ul style="list-style-type: none"> <li><input type="checkbox"/> prompting learners to explicitly formulate or restate learning goals</li> <li><input type="checkbox"/> displaying the learning goals in multiple ways</li> <li><input type="checkbox"/> using prompts or scaffolds for visualizing desired outcomes</li> <li><input type="checkbox"/> engaging assessment discussions of what constitutes excellence</li> <li><input type="checkbox"/> generating relevant examples with students that connect to their cultural background and interests</li> <li><input type="checkbox"/> providing alternatives in the math representations and scaffolds</li> <li><input type="checkbox"/> creating cooperative groups with clear goals, roles, responsibilities</li> <li><input type="checkbox"/> providing prompts to guide when and how to ask for help</li> <li><input type="checkbox"/> supporting opportunities for peer interactions and supports (e.g. peer tutors)</li> <li><input type="checkbox"/> constructing communities of learners engaged in common interests</li> <li><input type="checkbox"/> creating expectations for group work (e.g., rubrics, norms, etc.)</li> <li><input type="checkbox"/> providing feedback that encourages perseverance, focuses on development of efficacy and self-awareness, and encourages the use of specific supports and strategies in the face of challenge</li> <li><input type="checkbox"/> providing feedback that:                 <ul style="list-style-type: none"> <li><input type="checkbox"/> emphasizes effort, improvement, and achieving a standard rather than on relative performance</li> <li><input type="checkbox"/> is frequent, timely, and specific</li> <li><input type="checkbox"/> is informative rather than comparative or competitive</li> </ul> </li> </ul> </li> </ul> |

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|  | <ul style="list-style-type: none"> <li><input type="checkbox"/> models how to incorporate evaluation, including identifying patterns of errors and wrong answers, into positive strategies for future success</li> </ul>   |
| <p><b>REPRESENTATION</b></p> <p><input type="checkbox"/> How will the learning for students provide alternative representations to ensure accessibility, clarity and comprehensibility for all learners?</p> | <p><b>Language &amp; Symbols:</b></p> <p><input type="checkbox"/> What do you anticipate about the range of student background experience and vocabulary?</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Plan multiple methods for attending to linguistic and nonlinguistic representations of mathematics to ensure universal clarity by:             <ul style="list-style-type: none"> <li><input type="checkbox"/> pre-teaching vocabulary and symbols in ways that promote connection to the learners' experience and prior knowledge</li> <li><input type="checkbox"/> graphic symbols with alternative text descriptions</li> <li><input type="checkbox"/> highlighting how complex terms, expressions, or equations are composed of simpler words or symbols by attending to structure</li> <li><input type="checkbox"/> embedding support for vocabulary and symbols within the text (e.g., hyperlinks or footnotes to definitions, explanations, illustrations, previous coverage, translations)</li> <li><input type="checkbox"/> embedding support for unfamiliar references within the text (e.g., domain specific notation, lesser known properties and theorems, idioms, academic language, figurative language, mathematical language, jargon, archaic language, colloquialism, and dialect)</li> <li><input type="checkbox"/> highlighting structural relations or make them more explicit</li> <li><input type="checkbox"/> making connections to previously learned structures</li> <li><input type="checkbox"/> making relationships between elements explicit (e.g., highlighting the transition words in an argument, links between ideas, etc.)</li> <li><input type="checkbox"/> allowing the use of text-to-speech and automatic voicing with digital mathematical notation (math ml)</li> <li><input type="checkbox"/> allowing flexibility and easy access to multiple representations of notation where appropriate (e.g., formulas, word problems, graphs)</li> <li><input type="checkbox"/> clarification of notation through lists of key terms</li> <li><input type="checkbox"/> making all key information available in English also available in first languages (e.g., Spanish) for English Learners and in ASL for learners who are deaf</li> <li><input type="checkbox"/> linking key vocabulary words to definitions and pronunciations in both dominant and heritage languages</li> <li><input type="checkbox"/> defining domain-specific vocabulary (e.g., "map key" in social studies) using both domain-specific and common terms</li> <li><input type="checkbox"/> electronic translation tools or links to multilingual web glossaries</li> <li><input type="checkbox"/> embedding visual, non-linguistic supports for vocabulary clarification (pictures, videos, etc)</li> <li><input type="checkbox"/> presenting key concepts in one form of symbolic representation (e.g., math equation) with an alternative form (e.g., an illustration, diagram, table, photograph, animation, physical or virtual manipulative)</li> <li><input type="checkbox"/> making explicit links between information provided in texts and any accompanying representation of that information in illustrations, equations, charts, or diagrams</li> </ul> </li> </ul> |
| <p><b>ACTION &amp; EXPRESSION</b></p> <p><input type="checkbox"/> How will the learning provide multiple</p>   | <p><b>Expression &amp; Communication:</b></p> <p><input type="checkbox"/> What do you anticipate about the range in how students will express their thinking in the learning environment?</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Plan multiple methods for attending to the various ways in which students can express knowledge, ideas, and concepts by providing:</li> </ul>  |

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| <p>modalities for students to easily express knowledge, ideas, and concepts in the learning environment?</p> | <ul style="list-style-type: none"> <li><input type="checkbox"/> options to compose in multiple media such as text, speech, drawing, illustration, comics, storyboards, design, film, music, dance/movement, visual art, sculpture, or video</li> <li><input type="checkbox"/> use of social media and interactive web tools (e.g., discussion forums, chats, web design, annotation tools, storyboards, comic strips, animation presentations)</li> <li><input type="checkbox"/> flexibility in using a variety of problem solving strategies</li> <li><input type="checkbox"/> spell or grammar checkers, word prediction software</li> <li><input type="checkbox"/> text-to-speech software, human dictation, recording</li> <li><input type="checkbox"/> calculators, graphing calculators, geometric sketchpads, or pre-formatted graph paper</li> <li><input type="checkbox"/> sentence starters or sentence strips</li> <li><input type="checkbox"/> concept mapping tools</li> <li><input type="checkbox"/> Computer-Aided-Design (CAD) or mathematical notation software</li> <li><input type="checkbox"/> virtual or concrete mathematics manipulatives (e.g., base-10 blocks, algebra blocks)</li> <li><input type="checkbox"/> multiple examples of ways to solve a problem (i.e. examples that demonstrate the same outcomes but use differing approaches)</li> <li><input type="checkbox"/> multiple examples of novel solutions to authentic problems</li> <li><input type="checkbox"/> different approaches to motivate, guide, feedback or inform students of progress towards fluency</li> <li><input type="checkbox"/> scaffolds that can be gradually released with increasing independence and skills (e.g., embedded into digital programs)</li> <li><input type="checkbox"/> differentiated feedback (e.g., feedback that is accessible because it can be customized to individual learners)</li> </ul> |
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| <h2 style="text-align: center;">Optimizing INTERNALIZATION of the Learning Goal</h2>   |  |
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| <p><b>ENGAGEMENT</b></p> <p><input type="checkbox"/> How will the design of the learning strategically support students to effectively cope and engage with the environment?</p> | <p><b>Self-Regulation:</b></p> <p><input type="checkbox"/> What do you anticipate about barriers to student engagement?</p> <p><input type="checkbox"/> Plan to address barriers to engagement by promoting healthy responses and interactions, and ownership of learning goals:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> metacognitive approaches to frustration when doing mathematics</li> <li><input type="checkbox"/> increase length of on-task orientation through distractions</li> <li><input type="checkbox"/> frequent self-reflection and self-reinforcements</li> <li><input type="checkbox"/> address subject specific phobias and judgments of “natural” aptitude (e.g., “how can I improve on the areas I am struggling in?” rather than “I am not good at math”)</li> <li><input type="checkbox"/> offer devices, aids, or charts to assist students in learning to collect, chart and display data about the behaviors such as the math practices for the purpose of monitoring and improving</li> <li><input type="checkbox"/> use activities that include a means by which learners get feedback and have access to alternative scaffolds (e.g., charts, templates, feedback displays) that support understanding progress in a manner that is understandable and timely</li> </ul> |
| <p><b>REPRESENTATION</b></p> <p><input type="checkbox"/> How will the learning support transforming accessible information into usable knowledge</p>                             | <p><b>Comprehension:</b></p> <p><input type="checkbox"/> What do you anticipate about barriers to student comprehension?</p> <p><input type="checkbox"/> Plan to address barriers to comprehension by intentionally building connections to prior understandings and experiences, relating meaningful information to learning goals,</p>   |

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| <p>that is accessible for future learning and decision-making?</p>   | <p>providing a process for meaning making of new learning, and applying learning to new contexts:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> incorporate explicit opportunities for review and practice</li> <li><input type="checkbox"/> note-taking templates, graphic organizers, concept maps</li> <li><input type="checkbox"/> scaffolds that connect new information to prior knowledge (e.g., word webs, half-full concept maps)</li> <li><input type="checkbox"/> explicit, supported opportunities to generalize learning to new situations (e.g., different types of problems that can be solved with linear equations)</li> <li><input type="checkbox"/> opportunities over time to revisit key ideas and connections</li> <li><input type="checkbox"/> make explicit cross-curricular connections</li> <li><input type="checkbox"/> highlight key elements in tasks, graphics, diagrams, formulas</li> <li><input type="checkbox"/> outlines, graphic organizers, unit organizer routines, concept organizer routines, and concept mastery routines to emphasize key ideas and relationships</li> <li><input type="checkbox"/> multiple examples &amp; non-examples</li> <li><input type="checkbox"/> cues and prompts to draw attention to critical features</li> <li><input type="checkbox"/> highlight previously learned skills that can be used to solve unfamiliar problems</li> <li><input type="checkbox"/> options for organizing and possible approaches (tables and representations for processing mathematical operations)</li> <li><input type="checkbox"/> interactive representations that guide exploration and new understandings</li> <li><input type="checkbox"/> introduce graduated scaffolds that support information processing strategies</li> <li><input type="checkbox"/> tasks with multiple entry points and optional pathways</li> <li><input type="checkbox"/> “Chunk” information into smaller elements</li> <li><input type="checkbox"/> remove unnecessary distractions unless essential to learning goal</li> <li><input type="checkbox"/> anchor instruction by linking to and activating relevant prior knowledge (e.g., using visual imagery, concept anchoring, or concept mastery routines)</li> <li><input type="checkbox"/> pre-teach critical prerequisite concepts via demonstration or representations</li> <li><input type="checkbox"/> embed new ideas in familiar ideas and contexts (e.g., use of analogy, metaphor, drama, music, film, etc.)</li> <li><input type="checkbox"/> advanced organizers (e.g., KWL methods, concept maps)</li> <li><input type="checkbox"/> bridge concepts with relevant analogies and metaphors</li> </ul> |
| <p><b>ACCESS ACTION &amp; EXPRESSION</b></p> <p><input type="checkbox"/> How will the learning for students support the development of executive functions to allow them to take advantage of their environment?</p> | <p><b>Executive Functions:</b></p> <p><input type="checkbox"/> What do you anticipate about barriers to students demonstrating what they know?</p> <p><input type="checkbox"/> Plan to address barriers to demonstrating understanding by providing opportunities for students to set goals, formulate plans, use tools and processes to support organization and memory, and analyze their growth in learning and how to build from it:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> prompts and scaffolds to estimate effort, resources, difficulty</li> <li><input type="checkbox"/> models and examples of process and product of goal-setting</li> <li><input type="checkbox"/> guides and checklists for scaffolding goal-setting</li> <li><input type="checkbox"/> post goals, objectives, and schedules in an obvious place</li> <li><input type="checkbox"/> embed prompts to “show and explain your work”</li> <li><input type="checkbox"/> checklists and project plan templates for understanding the problem, prioritization, sequences, and schedules of steps</li> <li><input type="checkbox"/> embed coaches/mentors to demonstrate think-alouds of process</li> <li><input type="checkbox"/> guides to break long-term goals into short-term objectives</li> <li><input type="checkbox"/> graphic organizers/templates for organizing information &amp; data</li> <li><input type="checkbox"/> embed prompts for categorizing and systematizing</li> <li><input type="checkbox"/> checklists and guides for note-taking</li> <li><input type="checkbox"/> asking questions to guide self-monitoring and reflection</li> <li><input type="checkbox"/> showing representations of progress (e.g., before and after photos, graphs/charts showing progress, process portfolios)</li> </ul>  |

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|  | <ul style="list-style-type: none"> <li><input type="checkbox"/> prompt learners to identify type of feedback or advice they seek</li> <li><input type="checkbox"/> templates to guide self-reflection on quality &amp; completeness</li> <li><input type="checkbox"/> differentiated models of self-assessment strategies (e.g., role-playing, video reviews, peer feedback)</li> <li><input type="checkbox"/> assessment checklists, scoring rubrics, and multiple examples of annotated student work/performance examples</li> </ul> |
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## Planning Guidance for Culturally and Linguistically Responsive Instruction<sup>10</sup>

In order to ensure our students from marginalized cultures and languages view themselves as confident and competent learners and doers of mathematics within and outside of the classroom, educators must intentionally plan ways to counteract the negative or missing images and representations that exist in our curricular resources. The guiding questions below support the design of lessons that validate, affirm, build, and bridge home and school culture for learners of mathematics:

**Validate/Affirm:** How can you design your mathematics classroom to intentionally and purposefully legitimize the home culture and languages of students and reverse the negative stereotypes regarding the mathematical abilities of students of marginalized cultures and languages?

**Build/Bridge:** How can you create connections between the cultural and linguistic behaviors of your students' home culture and language and the culture and language of school mathematics to support students in creating mathematical identities as capable mathematicians that can use mathematics within school and society?

In addition, Aguirre and her colleagues<sup>11</sup> define **mathematical identities** as the dispositions and deeply held beliefs that students develop about their ability to participate and perform effectively in mathematical contexts and to use mathematics in powerful ways across the contexts of their lives. Many students see themselves as "not good at math" and approach math with fear and lack of confidence. Their identity, developed through earlier years of schooling, has the potential to affect their school and career choices.

### Five Equity-Based Mathematics Teaching Practices<sup>12</sup>

**Go deep with mathematics.** Develop students' conceptual understanding, procedural fluency, and problem solving and reasoning.

**Leverage multiple mathematical competencies.** Use students' different mathematical strengths as a resource for learning.

**Affirm mathematics learners' identities.** Promote student participation and value different ways of contributing.

<sup>10</sup> This resource relied heavily on the work of: Hollie, S. (2011). Culturally and linguistically responsive teaching and learning. Teacher Created Materials. (see also, <https://www.culturallyresponsive.org/vabb>)

<sup>11</sup> Aguirre, J. M., Mayfield-Ingram, K., & Martin, D. B. (2013). The impact of identity in K-8 mathematics learning and teaching: rethinking equity-based practices. Reston, VA: National Council of Teachers of Mathematics (p. 14).

<sup>12</sup> Boston, M., Dillon, F., & Miller, S. (2017). *Taking Action: Implementing Effective Mathematics Teaching Practices in Grades 9-12*. (M. S. Smith, Ed.). Reston, VA: National Council of Teacher of Mathematics, Inc. (p.6). (adapted from Aguirre, J. M., Mayfield-Ingram, K., & Martin, D. B. (2013) (p. 43).

**Challenge spaces of marginality.** Embrace student competencies, value multiple mathematical contributions, and position students as sources of expertise.

**Draw on multiple resources of knowledge** (mathematics, language, culture, family). Tap students' knowledge and experiences as resources for mathematics learning.

The following lesson design strategies support Culturally and Linguistically Responsive Instruction, specific examples for each cluster of standards can be found in part 2 of the document. These were adapted from the Promoting Equity section of the Taking Action series published by NCTM.<sup>13</sup>

**Goal Setting:** Setting challenging but attainable goals with students can communicate the belief and expectation that all students can engage with interesting and rigorous mathematical content and achieve in mathematics. Unfortunately, the reverse is also true, when students encounter low expectations through their interactions with adults and the media, they may see little reason to persist in mathematics, which can create a vicious cycle of low expectations and low achievement.

**Mathematical Tasks:** The type of mathematical tasks and instruction students receive provides the foundation for students' mathematical learning and their mathematical identity. Tasks and instruction that provide greater access to the mathematics and convey the creativity of mathematics by allowing for multiple solution strategies and development of the standards for mathematical practice lead to more students viewing themselves mathematically successful capable mathematicians than tasks and instruction which define success as memorizing and repeating a procedure demonstrated by the teacher.

**Modifying Mathematical Tasks:** When planning with your HQIM consider how to modify tasks to represent the prior experiences, culture, language and interests of your students to "portray mathematics as useful and important in students' lives and promote students' lived experiences as important in mathematics class." Tasks can also be designed to "promote social justice [to] engage students in using mathematics to understand and eradicate social inequities (Gutstein 2006)."

**Building Procedural Fluency from Conceptual Understanding:** Instruction should build from conceptual understanding to allow students opportunities to make meaning of mathematics before focusing on procedures. When new learning begins with procedures it privileges those with strong prior familiarity with school mathematics procedures for solving problems and does not allow learning to build for more methods for solving tasks that occur outside of school mathematics.

**Posing Purposeful Questions:** CLRI requires intentional planning around the questions posed in a mathematics classroom. It is critical to consider "who is being positioned as competent, and whose ideas are featured and privileged" within the classroom through both the types of questioning and who is being questioned. Mathematics classrooms traditionally ask short answer questions and reward students that can respond quickly and correctly. When questioning seeks to understand students' thinking by taking their ideas seriously and asking the community to build upon one another's ideas a greater sense of belonging in mathematics is created for students from marginalized cultures and languages.

**Using and Connecting Mathematical Representations:** The standard for mathematical practice, use appropriate tools strategically, provides a strong foundation to validate and bridge for students. Mathematical representations are mathematical tools. The linguistic and cultural experiences of students provide different and varied types of representations for solving mathematical problems. By explicitly encouraging students to use multiple mathematical representations students can draw on their "mathematical, social, and cultural competence". By valuing these representations and discussing them we

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<sup>13</sup> Boston, M., Dillon, F., & Miller, S. (2017). *Taking Action: Implementing Effective Mathematics Teaching Practices in Grades 9-12*. (M. S. Smith, Ed.). Reston, VA: National Council of Teacher of Mathematics, Inc.

can connect student representations to the representations of school mathematics and build a bridge for students to position them as competent and capable mathematicians.

**Facilitating Meaningful Mathematical Discourse:** Mathematics discourse requires intentional planning to ensure all students feel comfortable to share, consider, build upon and critique the mathematical ideas under consideration. When student ideas serve as the basis for discussion we position them as knowers and doers of mathematics by using equitable talk moves students and attending to the ways students talk about who is and isn't capable of mathematics we can disrupt the negative images and stereotypes around mathematics of marginalized cultures and languages. "A discourse-based mathematics classroom provides stronger access for every student — those who have an immediate answer or approach to share, those who have begun to formulate a mathematical approach to a task but have not fully developed their thoughts, and those who may not have an approach but can provide feedback to others."

**Eliciting and Using Evidence of Student Thinking:** Eliciting and using student thinking can promote a classroom culture in which mistakes or errors are viewed as opportunities for learning. When student thinking is at the center of classroom activity, "it is more likely that students who have felt evaluated or judged in their past mathematical experiences will make meaningful contributions to the classroom over time."

**Supporting Productive Struggle in Learning Mathematics:** The standard for mathematical practice, makes sense of mathematics and persevere in solving them is the foundation for supporting productive struggle in the mathematics classroom. "Too frequently, historically marginalized students are overrepresented in classes that focus on memorizing and practicing procedures and rarely provide opportunities for students to think and figure things out for themselves. When students in these classes struggle, the teacher often tells them what to do without building their capacity for persistence." Teachers need to provide tasks that challenge students and maintain that challenge while encouraging them to persist. This encouragement or "warm-demander" requires a strong relationship with students and an understanding of the culture of the students.



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## Glossary<sup>14</sup>

**Addition and subtraction within 5, 10, 20, 100, or 1000.** Addition or subtraction of two whole numbers with whole number answers, and with sum or minuend in the range 0-5, 0-10, 0-20, or 0-100, respectively. Example:  $8 + 2 = 10$  is an addition within 10,  $14 - 5 = 9$  is a subtraction within 20, and  $55 - 18 = 37$  is a subtraction within 100.

**Additive inverses.** Two numbers whose sum is 0 are additive inverses of one another. Example:  $3/4$  and  $-3/4$  are additive inverses of one another because  $3/4 + (-3/4) = (-3/4) + 3/4 = 0$ .

**Associative property of addition.** See Table 3 in this Glossary.

**Associative property of multiplication.** See Table 3 in this Glossary.

**Bivariate data.** Pairs of linked numerical observations. Example: a list of heights and weights for each player on a football team.

**Box plot.** A method of visually displaying a distribution of data values by using the median, quartiles, and extremes of the data set. A box shows the middle 50% of the data.<sup>15</sup>

**Commutative property.** See Table 3 in this Glossary.

**Complex fraction.** A fraction  $A/B$  where  $A$  and/or  $B$  are fractions ( $B$  nonzero).

**Computation algorithm.** A set of predefined steps applicable to a class of problems that gives the correct result in every case when the steps are carried out correctly. See also: computation strategy.

**Computation strategy.** Purposeful manipulations that may be chosen for specific problems, may not have a fixed order, and may be aimed at converting one problem into another. See also: computation algorithm.

**Congruent.** Two plane or solid figures are congruent if one can be obtained from the other by rigid motion (a sequence of rotations, reflections, and translations).

**Counting on.** A strategy for finding the number of objects in a group without having to count every member of the group. For example, if a stack of books is known to have 8 books and 3 more books are added to the top, it is not necessary to count the stack all over again. One can find the total by counting on—pointing to the top book and saying “eight,” following this with “nine, ten, eleven. There are eleven books now.”

**Dot plot.** See: line plot.

**Dilation.** A transformation that moves each point along the ray through the point emanating from a fixed center, and multiplies distances from the center by a common scale factor.

**Expanded form.** A multi-digit number is expressed in expanded form when it is written as a sum of single-digit multiples of powers of ten. For example,  $643 = 600 + 40 + 3$ .

**Expected value.** For a random variable, the weighted average of its possible values, with weights given by their respective probabilities.

<sup>14</sup> Glossary and tables taken from: Common Core State Standards Initiative. (2020). Mathematics Glossary | Common Core State Standards Initiative. Retrieved from <http://www.corestandards.org/Math/Content/mathematics-glossary/>

<sup>15</sup> Adapted from Wisconsin Department of Public Instruction, <http://dpi.wi.gov/standards/mathglos.html>, accessed March 2, 2010.

**First quartile.** For a data set with median  $M$ , the first quartile is the median of the data values less than  $M$ . Example: For the data set  $\{1, 3, 6, 7, 10, 12, 14, 15, 22, 120\}$ , the first quartile is 6.<sup>16</sup> See also: median, third quartile, interquartile range.

**Fraction.** A number expressible in the form  $a/b$  where  $a$  is a whole number and  $b$  is a positive whole number. (The word fraction in these standards always refers to a non-negative number.) See also: rational number.

**Identity property of 0.** See Table 3 in this Glossary.

**Independently combined probability models.** Two probability models are said to be combined independently if the probability of each ordered pair in the combined model equals the product of the original probabilities of the two individual outcomes in the ordered pair.

**Integer.** A number expressible in the form  $a$  or  $-a$  for some whole number  $a$ .

**Interquartile Range.** A measure of variation in a set of numerical data, the interquartile range is the distance between the first and third quartiles of the data set. Example: For the data set  $\{1, 3, 6, 7, 10, 12, 14, 15, 22, 120\}$ , the interquartile range is  $15 - 6 = 9$ . See also: first quartile, third quartile.

**Line plot.** A method of visually displaying a distribution of data values where each data value is shown as a dot or mark above a number line.

Also known as a dot plot.<sup>17</sup>

**Mean.** A measure of center in a set of numerical data, computed by adding the values in a list and then dividing by the number of values in the list.<sup>18</sup> Example: For the data set  $\{1, 3, 6, 7, 10, 12, 14, 15, 22, 120\}$ , the mean is 21.

**Mean absolute deviation.** A measure of variation in a set of numerical data, computed by adding the distances between each data value and the mean, then dividing by the number of data values. Example: For the data set  $\{2, 3, 6, 7, 10, 12, 14, 15, 22, 120\}$ , the mean absolute deviation is 20.

**Median.** A measure of center in a set of numerical data. The median of a list of values is the value appearing at the center of a sorted version of the list—or the mean of the two central values, if the list contains an even number of values. Example: For the data set  $\{2, 3, 6, 7, 10, 12, 14, 15, 22, 90\}$ , the median is 11.

**Midline.** In the graph of a trigonometric function, the horizontal line halfway between its maximum and minimum values. Multiplication and division within 100. Multiplication or division of two whole numbers with whole number answers, and with product or dividend in the range 0-100. Example:  $72 \div 8 = 9$ .

**Multiplicative inverses.** Two numbers whose product is 1 are multiplicative inverses of one another. Example:  $3/4$  and  $4/3$  are multiplicative inverses of one another because  $3/4 \cdot 4/3 = 4/3 \cdot 3/4 = 1$ .

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<sup>16</sup> Many different methods for computing quartiles are in use. The method defined here is sometimes called the Moore and McCabe method. See Langford, E., "Quartiles in Elementary Statistics," *Journal of Statistics Education* Volume 14, Number 3 (2006).

<sup>17</sup> Adapted from Wisconsin Department of Public Instruction, op. cit.

<sup>18</sup> To be more precise, this defines the arithmetic mean.

**Number line diagram.** A diagram of the number line used to represent numbers and support reasoning about them. In a number line diagram for measurement quantities, the interval from 0 to 1 on the diagram represents the unit of measure for the quantity.

**Percent rate of change.** A rate of change expressed as a percent. Example: if a population grows from 50 to 55 in a year, it grows by  $5/50 = 10\%$  per year.

**Probability distribution.** The set of possible values of a random variable with a probability assigned to each.

**Properties of operations.** See Table 3 in this Glossary.

**Properties of equality.** See Table 4 in this Glossary.

**Properties of inequality.** See Table 5 in this Glossary.

**Properties of operations.** See Table 3 in this Glossary.

**Probability.** A number between 0 and 1 used to quantify likelihood for processes that have uncertain outcomes (such as tossing a coin, selecting a person at random from a group of people, tossing a ball at a target, or testing for a medical condition).

**Probability model.** A probability model is used to assign probabilities to outcomes of a chance process by examining the nature of the process. The set of all outcomes is called the sample space, and their probabilities sum to 1. *See also:* uniform probability model.

**Random variable.** An assignment of a numerical value to each outcome in a sample space. Rational expression. A quotient of two polynomials with a non-zero denominator.

**Rational number.** A number expressible in the form  $a/b$  or  $-a/b$  for some fraction  $a/b$ . The rational numbers include the integers.

**Rectilinear figure.** A polygon all angles of which are right angles.

**Rigid motion.** A transformation of points in space consisting of a sequence of one or more translations, reflections, and/or rotations. Rigid motions are here assumed to preserve distances and angle measures.

**Repeating decimal.** The decimal form of a rational number. *See also:* terminating decimal.

**Sample space.** In a probability model for a random process, a list of the individual outcomes that are to be considered.

**Scatter plot.** A graph in the coordinate plane representing a set of bivariate data. For example, the heights and weights of a group of people could be displayed on a scatter plot.<sup>19</sup>

**Similarity transformation.** A rigid motion followed by a dilation.

**Tape diagram.** A drawing that looks like a segment of tape, used to illustrate number relationships. Also known as a strip diagram, bar model, fraction strip, or length model.

**Terminating decimal.** A decimal is called terminating if its repeating digit is 0.

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<sup>19</sup> Adapted from Wisconsin Department of Public Instruction, op. cit.

**Third quartile.** For a data set with median M, the third quartile is the median of the data values greater than M. Example: For the data set {2, 3, 6, 7, 10, 12, 14, 15, 22, 120}, the third quartile is 15. See also: median, first quartile, interquartile range.

Table 1: Common addition and subtraction.<sup>1</sup>

|  | <b>RESULT UNKNOWN</b>   | <b>CHANGE UNKNOWN</b>   | <b>START UNKNOWN</b>  |
|--|---|---|---|
| <b>ADD TO</b>                                | Two bunnies sat on the grass. Three more bunnies hopped there. How many bunnies are on the grass now? $2 + 3 = ?$   | Two bunnies were sitting on the grass. Some more bunnies hopped there. Then there were five bunnies. How many bunnies hopped over to the first two? $2 + ? = 5$   | Some bunnies were sitting on the grass. Three more bunnies hopped there. Then there were five bunnies. How many bunnies were on the grass before? $? + 3 = 5$   |
| <b>TAKE FROM</b>                             | Five apples were on the table. I ate two apples. How many apples are on the table now? $5 - 2 = ?$  | Five apples were on the table. I ate some apples. Then there were three apples. How many apples did I eat? $5 - ? = 3$  | Some apples were on the table. I ate two apples. Then there were three apples. How many apples were on the table before? $? - 2 = 3$  |
|  | <b>TOTAL UNKNOWN</b>  | <b>ADDEND UNKNOWN</b>   | <b>BOTH ADDENDS UNKNOWN<sup>2</sup></b>   |
| <b>PUT TOGETHER / TAKE APART<sup>3</sup></b> | Three red apples and two green apples are on the table. How many apples are on the table? $3 + 2 = ?$   | Five apples are on the table. Three are red and the rest are green. How many apples are green? $3 + ? = 5$ , $5 - 3 = ?$  | Grandma has five flowers. How many can she put in the red vase and how many in her blue vase? $5 = 0 + 5$ , $5 = 0 + 5$ , $5 = 1 + 4$ , $5 = 4 + 1$ , $5 = 2 + 3$ , $5 = 3 + 2$   |
| <b>COMPARE</b>                               | <b>DIFFERENCE UNKNOWN</b>   | <b>BIGGER UNKNOWN</b>   | <b>SMALLER UNKNOWN</b>  |
|  | (“How many more?” version): Lucy has two apples. Julie has five apples. How many more apples does Julie have than Lucy? (“How many fewer?” version): Lucy has two apples. Julie has five apples. How many fewer apples does Lucy have than Julie? $2 + ? = 5$ , $5 - 2 = ?$ | (Version with “more”): Julie has three more apples than Lucy. Lucy has two apples. How many apples does Julie have? (Version with “fewer”): Lucy has 3 fewer apples than Julie. Lucy has two apples. How many apples does Julie have? $2 + 3 = ?$ , $3 + 2 = ?$ | (Version with “more”): Julie has three more apples than Lucy. Julie has five apples. How many apples does Lucy have? (Version with “fewer”): Lucy has 3 fewer apples than Julie. Julie has five apples. How many apples does Lucy have? $5 - 3 = ?$ , $? + 3 = 5$ |

<sup>1</sup>Adapted from Box 2-4 of Mathematics Learning in Early Childhood, National Research Council (2009, pp. 32, 33).

<sup>2</sup>These take apart situations can be used to show all the decompositions of a given number. The associated equations, which have the total on the left of the equal sign, help children understand that the = sign does not always mean, makes or results in but always does mean is the same number as.

<sup>3</sup>Either addend can be unknown, so there are three variations of these problem situations. Both addends Unknown is a productive extension of the basic situation, especially for small numbers less than or equal to 10.

<sup>4</sup>For the Bigger Unknown or Smaller Unknown situations, one version directs the correct operation (the version using more for the bigger unknown and using less for the smaller unknown). The other versions are more difficult.

Table 2: Common multiplication and division situations.<sup>1</sup>

|   | <b>UNKNOWN PRODUCT</b>  | <b>GROUP SIZE UNKNOWN (“HOW MANY IN EACH GROUP?” DIVISION)</b>  | <b>NUMBER OF GROUPS UNKNOWN (“HOW MANY GROUPS?” DIVISION)</b>  |
|---|---|---|--|
|   | $3 \times 6 = ?$  | $3 \times ? = 18$ , and $18 \div 3 = ?$   | $? \times 6 = 18$ , and $18 \div 6 = ?$  |
| <b>EQUAL GROUPS</b>                         | There are 3 bags with 6 plums in each bag. How many plums are there in all? <i>Measurement example.</i> You need 3 lengths of string, each 6 inches long. How much string will you need altogether?   | If 18 plums are shared equally into 3 bags, then how many plums will be in each bag? <i>Measurement example.</i> You have 18 inches of string, which you will cut into 3 equal pieces. How long will each piece of string be?                                       | If 18 plums are to be packed 6 to a bag, then how many bags are needed? <i>Measurement example.</i> You have 18 inches of string, which you will cut into pieces that are 6 inches long. How many pieces of string will you have?  |
| <b>ARRAYS<sup>2</sup>, AREA<sup>3</sup></b> | There are 3 rows of apples with 6 apples in each row. How many apples are there? <i>Area example.</i> What is the area of a 3 cm by 6 cm rectangle?   | If 18 apples are arranged into 3 equal rows, how many apples will be in each row? <i>Area example.</i> A rectangle has area 18 square centimeters. If one side is 3 cm long, how long is a side next to it?   | If 18 apples are arranged into equal rows of 6 apples, how many rows will there be? <i>Area example.</i> A rectangle has area 18 square centimeters. If one side is 6 cm long, how long is a side next to it?  |
| <b>COMPARE</b>                              | A blue hat costs \$6. A red hat costs 3 times as much as the blue hat. How much does the red hat cost? <i>Measurement example.</i> A rubber band is 6 cm long. How long will the rubber band be when it is stretched to be 3 times as long? | A red hat costs \$18 and that is 3 times as much as a blue hat costs. How much does a blue hat cost? <i>Measurement example.</i> A rubber band is stretched to be 18 cm long and that is 3 times as long as it was at first. How long was the rubber band at first? | A red hat costs \$18 and a blue hat costs \$6. How many times as much does the red hat cost as the blue hat? <i>Measurement example.</i> A rubber band was 6 cm long at first. Now it is stretched to be 18 cm long. How many times as long is the rubber band now as it was at first? |
| <b>GENERAL</b>                              | $a \times b = ?$  | $a \times ? = p$ and $p \div a = ?$   | $? \times b = p$ , and $p \div b = ?$  |

<sup>1</sup>The language in the array examples shows the easiest form of array problems. A harder form is to use the terms rows and columns: The apples in the grocery window are in 3 rows and 6 columns. How many apples are in there? Both forms are valuable.

<sup>2</sup>Area involves arrays of squares that have been pushed together so that there are no gaps or overlaps, so array problems include these especially important measurement situations.

<sup>3</sup>The first examples in each cell are examples of discrete things. These are easier for students and should be given before the measurement examples.

Table 3: The properties of operations.

Here a, b and c stand for arbitrary numbers in a given number system. The properties of operations apply to the rational number system, the real number system, and the complex number.

|                                  |                             |
|----------------------------------|-----------------------------|
| Associative property of addition | $(a + b) + c = a + (b + c)$ |
| Commutative property of addition | $a + b = b + a$             |

|  |   |
|--|---|
| Additive identity property of 0                        | $a + 0 = 0 + a = a$   |
| Existence of additive inverses                         | For every $a$ there exists $-a$ so that $a + (-a) = (-a) + a = 0$                 |
| Associative property of multiplication                 | $(a \times b) \times c = a \times (b \times c)$                                   |
| Commutative property of multiplication                 | $a \times b = b \times a$   |
| Multiplicative identity property 1                     | $a \times 1 = 1 \times a = a$   |
| Existence of multiplicative inverses                   | For every $a \neq 0$ there exists $1/a$ so that $a \times 1/a = 1/a \times a = 1$ |
| Distributive property of multiplication over additions | $a \times (b + c) = a \times b + a \times c$                                      |

Table 4: The properties of equality.

Here  $a$ ,  $b$  and  $c$  stand for arbitrary numbers in the rational, real, or complex number systems.

|                                     |   |
|-------------------------------------|---|
| Reflexive property of equality      | $a = a$ .   |
| Symmetric property of equality      | If $a = b$ , then $b = a$ .   |
| Transitive property of equality     | If $a = b$ and $b = c$ , then $a = c$ .   |
| Addition property of equality       | If $a = b$ , then $a + c = b + c$ .   |
| Subtraction property of equality    | If $a = b$ then $a - c = b - c$ .   |
| Multiplication property of equality | If $a = b$ , then $a \times c = b \times c$ .                                       |
| Division property of equality       | If $a = b$ and $c \neq 0$ , then $a \div c = b \div c$ .                            |
| Substitution property of equality   | If $a = b$ , then $b$ may be substituted for $a$ in any expression containing $a$ . |

Table 5. The properties of inequality.

Here  $a$ ,  $b$ , and  $c$  stand for arbitrary numbers in the rational or real number systems.

|   |
|---|
| Exactly one of the following is true: $a < b$ , $a = b$ , $a > b$ . |
| If $a > b$ and $b > c$ then $a > c$ .                               |
| If $a > b$ , $b < a$ .  |
| If $a > b$ , then $-a < -b$ .                                       |
| If $a > b$ , then $a \pm c > b \pm c$ .                             |
| If $a > b$ and $c > 0$ , then $a \times c > b \times c$ .           |
| If $a > b$ and $c < 0$ , then $a \times c < b \times c$ .           |
| If $a > b$ and $c > 0$ , then $a \div c > b \div c$ .               |
| If $a > b$ and $c < 0$ , then $a \div c < b \div c$ .               |