

Improving Mathematics Performance



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Overview

In an effective mathematics program, students learn to reason and communicate mathematically, value mathematics, and become confident in their own mathematical abilities to solve problems in situations that may not be familiar to them. Students need to be equipped as confident, competent, engaged, and persistent problem solvers. The key to mathematical competence is learning with understanding so that students are able to reason, solve problems, and apply their learning to new situations. Students need to be computationally fluent to carry out mathematical procedures flexibly, accurately, efficiently, and appropriately.

Students need to be able to understand and use mathematics in everyday life. This understanding must be continually strengthened and expanded throughout their educational experiences.

For a complete perspective on AYP, along with additional contacts and the entire AYP Handbook, visit: http://dpi.wi.gov/ssos/ayp_handbook.html.


Strong mathematics programs also address the needs of all students, including struggling and highly able students. Early opportunities should be provided for one-on-one or small group assistance. To the extent possible, such supports should not interfere with the student's participation in regular classroom activities and learning. It is important that all students have access to rigorous mathematics, opportunities to engage in rich discourse about mathematics and expectations to think about their mathematical thinking. It is also important to use formative assessment practices to identify when students struggle and to intervene early.

Mathematical proficiency is something that all students can and need to achieve, just as all students need to become proficient readers. "Mathematical proficiency is not something students accomplish when they reach eighth grade or twelfth grade; they can be proficient regardless of their grade. Moreover, mathematical proficiency can no longer be restricted to a select few" (*Helping Children Learn Mathematics*, National Research Council 2002). Five areas of mathematical proficiency can be viewed as strands of an intertwined rope: *Conceptual Understanding, Procedural Fluency, Strategic Competence, Adaptive Reasoning, and Productive Disposition*. (*Adding It Up*, National Research Council, 2002) In practice, educators need to consider making sure that students:

- Understand important mathematical concepts, operations, and relations.
- Develop procedural fluency to carry out procedures flexibly, accurately, efficiently, and appropriately.
- Are strategic in their thinking and problem solving, able to formulate, represent, and solve mathematical problems.
- Are able to reason and have the capacity for logical thought, reflection, explanation, and justification.
- Have positive attitudes about math and confidence in their mathematical abilities and have developed an ability to persist.
- See math as something that makes sense, is useful and worthwhile, and is applicable to real-life.

Action Options

Focus on curriculum, instruction, and assessment

- Review the district mathematics curriculum to ensure that it is aligned with the Wisconsin Model Academic Standards at: <http://www.dpi.wi.gov/standards/matintro.html>.
 - Consider instituting a daily math block of at least 60 minutes into your school schedule. Research indicates that extending instructional time for mathematics enhances student achievement.
 - Evaluate the mathematics curriculum to ensure that, at all levels, the curriculum addresses mathematical content standards (number operations and relationships, geometry, measurement, statistics and probability, and algebraic relationships), and mathematical process standards (reasoning, communication, connections, representation, and routine and non-routine problem solving).
 - Review instruction to ensure that the intended curriculum has been delivered. One of the areas of concern in mathematics is the *Opportunity to Learn* (OTL), which refers to what students have studied and therefore have had a chance to learn each year. A close examination of both the intended curriculum and the delivered curriculum may point out inconsistencies that must be addressed. Is one particular topic of mathematics not being covered? For example, it may be difficult for students to construct or analyze a stem-and-leaf plot on the state test if it is not part of the curriculum.
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- Research has shown that being in the classroom of a highly qualified and effective teacher has significant impact on students' achievement for multiple years. Assign strong mathematics teachers to target grade levels or courses (e.g., ninth-grade algebra or level 1 of an integrated mathematics program).
 - Consider reallocating teaching staff or designating funds for a math coach, math teacher-leader or math specialist positions. Adopt content-focused coaching or another model to focus on teaching and learning. See recommendations from 2008 National Mathematics Panel Report: <http://www.ed.gov/about/bdscomm/list/mathpanel/report/final-factsheet.html>
 - Learning with understanding means that students are engaged in making sense of mathematics. Do students learn mathematics with understanding, or does the curriculum primarily focus on rote memorization of "important formulas"? Young children need to have multiple opportunities to fully grasp an understanding of equality so that when asked to solve $3 + 5 = _ + 2$, the response is not "8" because their primary experiences with equality have been with examples such as $4 + 2 = _$. Older students, for example, need experiences with building an understanding of spatial relationships and knowing what makes the graphs of linear, quadratic, and exponential functions differ.
 - Encourage instructional practices that ensure that students communicate their mathematical strategies and understandings. Communicating mathematically (speaking and writing) helps to deepen students' understanding and gives teachers opportunities to identify misconceptions and more reliably assess what students know.
 - Encourage mathematics experiences that provide students with a range of depth and higher-order thinking skills. Do students have regular experiences solving non-routine, open-ended problems? Are questions constructed with higher-order thinking skills in mind? For example, in one task students are asked to name various shapes (square, trapezoid, parallelogram, etc.). In a second task, students are asked to sort several shapes (square, rhombus, trapezoid, right triangle, hexagon, and pentagon) into two or three categories and explain how they were sorted. An extension question might ask students to draw a different shape that would fit each category. The first task is recall (low-level thinking); whereas the other two tasks expect students to reason, communicate, and generalize at much higher thinking levels.

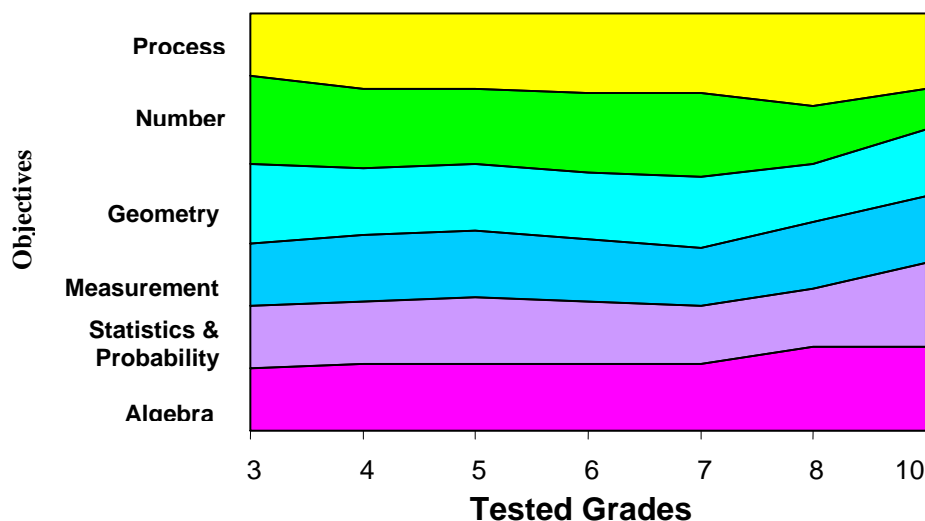
- Teach the “language of mathematics.” Do students learn how to use mathematical terminology when explaining their thinking and justifying results? How do English Language Learners receive support?
- Emphasize the importance and varied purposes of multiple kinds of formative assessment and use information to guide instruction.
- Identify common assessment items and provide opportunities for teachers to collaboratively evaluate student work and discuss teaching strategies.
- Use student work samples as instructional tools. Ask students to evaluate responses based on a rubric. How can the response be improved to clearly demonstrate understanding? What misconceptions are evident in the work sample?
- Build new understanding on previous experiences.
- Help students strengthen mathematical reasoning and problem solving by seeing the connections between mathematics and other subjects through the integration of mathematics across content area projects.
- Make the tools of mathematics, including manipulatives, measuring tools and technology, readily available in every classroom. Provide support and expectations for using them during instruction.
- Evaluate the use of calculators and computers at all levels as tools of mathematics that are used to build understanding of new concepts, evaluate reasonableness, analyze data, and make and test mathematical conjectures. The Wisconsin Mathematics Council Position on Calculator Use states:

The calculator is a valuable tool in teaching, learning, and assessment. Appropriate calculator use complements computational fluency. Appropriate calculator use includes selecting a calculator suitable to the level of the student and the curricular content; using calculators in a way that furthers the understanding of mathematics; being deliberate about when it is best to use calculators, when it is best to use mental math, estimation, paper and pencil, or other methods; and having calculators available for interdisciplinary applications.




- Work with the entire staff to develop a core set of beliefs about mathematics instruction and learning (e.g., all students, regardless of gender, ethnicity, race, economic status, or disability, can learn and be successful in mathematics, can benefit from exposure to higher-level mathematics, and deserve to be taught by highly qualified teachers).
- Provide opportunities to review assessment data (including time analysis across levels). This may point out mathematics content and process areas that are either not addressed or insufficiently addressed in the curriculum.
- Use the WKCE Assessment Frameworks for Mathematics as a tool to ensure that the district curriculum has addressed each of the objectives, subskills, and grade-level descriptors prior to administering statewide assessments. However, understand that the Frameworks is not the curriculum, it simply defines the scope of what is covered on the state test. For additional information, see: http://dpi.wi.gov/oea/pdf/math_framework.pdf. A wealth of information related to the Wisconsin Alternate Assessment for Students with Disabilities can be found at: <http://dpi.wi.gov/oea/waa.html>.
- The WKCE Mathematics Assessment Blueprint, as found in the Assessment Frameworks for Mathematics, shows the distribution of score points across the test item bank at grades 3–8 and 10. The objectives measured are: Mathematical Process, Number Operations and Relationships, Geometry, Measurement, Statistics and Probability, and Algebraic Relationship.

WKCE Mathematics Assessment Blueprint



Provide opportunities for meaningful professional development

- Providing a sustained professional development plan is especially important for mathematics educators. Teachers need professional development that focuses on both content and pedagogy, including best practices, understanding how students learn, and how to continually assess student understanding of important mathematics concepts.
- Provide professional development that focuses on mathematical content so that teachers have the opportunity to build an increased understanding of important mathematics, as well as an understanding of common misconceptions..
- As much as possible, provide professional development that is embedded in practice where teachers examine student work from their own classrooms and incorporate and reflect on instructional strategies that they use with their students.
- Ensure that the staff has the ability to develop mathematical thinking in their students.
 - Promote problem-solving skills by asking questions such as *What information do you have? What strategies will you use? What tools will you need?*
 - Reinforce connections among ideas by asking *What ideas have we used before that were useful in solving this problem? What uses of mathematics did you find in the newspaper last night? Can you give me an example of...?*
 - Encourage reflection by asking *Does your answer seem reasonable? Can you describe your method to us all? What are the key points in this lesson?*
 - Help students learn to reason by asking *How would you prove that? Can you think of a counterexample? What assumptions are you making?*
 - Encourage conjecturing by asking *What would happen if...? Do you see a pattern?*
- Involve all mathematics teachers in an analysis/alignment study of the connections between the district curriculum and the WKCE Assessment Framework for Mathematics. This is an opportunity for teachers to review their grade-level curriculum and the continuum between levels with the assessment blueprint.
- Provide opportunities for vertical planning, allowing educators to understand where the mathematics they teach fits into the scope of the K–12 curriculum. Educators should identify the vocabulary used and formulate ways to embed it in instruction so that teaching and learning are consistent at all levels. Teachers need to understand the construct of the mathematics program so that they know when concepts and skills are introduced, reinforced, and secure. This may help to ensure that important concepts are adequately addressed and may reduce unnecessary repetition.

- Consider establishing professional learning communities that support mathematics teaching and learning.
- Review the mathematics understanding and background of all who support mathematics. Be certain that special education teachers, Title I teachers, and instructional assistants are trained in the district mathematics curriculum and receive ongoing support regarding effective strategies to work with struggling mathematics students. Be certain that tutors and volunteers are equipped with strategies to effectively support and intervene in a manner consistent with the district curriculum and instruction. 
- Provide opportunities for staff to collaboratively analyze assessment data, including state, district, and common classroom assessments. Have discussions about understandings and misconceptions of important mathematical ideas as evidenced in the data. Carefully review the distracters (incorrect answers) that students choose. This may point out either gaps in the curriculum or mathematical misunderstandings of both students and staff.
- Be certain that staff is familiar with current research, including post-secondary success linked to mathematics courses students take in high school. (*Improving Adolescent Mathematics, Findings from Research*, Northwest Regional Educational Laboratory)
- Provide professional development opportunities outside of the district through summer Wisconsin Academy Staff Development Initiative (WASDI) Academics (<http://www.wasdi.org/>) or Wisconsin Mathematics Council (<http://www.wismath.org>) and Cooperative Educational Service Agency (<http://dpi.wi.gov/cesa.html>) workshops. Contact neighboring districts that may be providing professional development training.
- Encourage staff members at all levels to be professionally active in the Wisconsin Mathematics Council (WMC) (<http://www.wismath.org>) and National Council of Teachers of Mathematics (<http://www.nctm.org>). Consider supporting a mathematics leader in your district to participate in the Wisconsin Mathematics Leadership Council (WIMLC). All organizations offer opportunities for professional development and networking. The annual WMC conference is in early May, preceded by a leadership pre-conference.
- Collaborate with local colleges and universities to become a grant partner, for example, Title II, Part B—Math and Science Partnerships (<http://dpi.wi.gov/cal/t2bgrant.html>).

Offer support for struggling students, students with disabilities and English Language Learners

- Support struggling students in the regular education classroom as much as possible. Too often, struggling students have been pulled out of regular education mathematics classrooms and receive mathematics instruction that may be primarily focused on skills and computation with little or no opportunity to solve rich mathematical problems or be expected to communicate mathematical reasoning.
- Identify students who are struggling early. Regularly assess students' academic progress and identify the students who need help. Employ creative scheduling to give these students extra assistance during study hall, before school, after school, or in summer sessions. Early intervention such as working in small groups as well as one-on-one and peer tutoring at all levels may avoid significant gaps in learning for many at-risk students.
- Establish a way to identify students who either do or are likely to struggle with important concepts and skills. Provide early intervention support structure so that these students receive additional opportunities before they fall significantly behind.
- If mathematics has been identified as one of the school's priorities through a Title I comprehensive needs assessment, funding can be used to support mathematics in eligible schools.

- Assign additional teachers or paraprofessionals to mixed-ability classrooms that include low-achieving mathematics students. Be certain that there is time for teachers to collaborate in order to discuss strategies that will enhance student learning and clarify roles of teachers and support personnel during the lessons.
- Use a variety of scenarios to support struggling students, including structuring activities that will give those students an opportunity to build background knowledge and experiences prior to important concept lessons. Be certain that the activities, lessons, and curriculum used to support struggling students address the needs of the students, complement and reinforce the existing curriculum, and are aligned with district and state standards.
- Set high standards for demonstrating classroom proficiency and establish procedures for those who do not meet the criteria. For example, require students who receive a less than satisfactory semester grade in mathematics to participate in a guided study hall, take an additional course, or attend summer sessions.
- Because the language of mathematics contains vocabulary that has multiple meanings or is not readily used or understood by all students, it is important to present mathematics language both in the classroom and in test preparation to be sure that students know, understand, and can apply relevant vocabulary. Mathematics-specific vocabulary may be unfamiliar to students who struggle with language.
- Incorporate questions that encourage higher-order thinking for struggling students.
- Identify instructional strategies that increase student accessibility to mathematics. When planning lessons, consider potential barriers and difficulties students may have. The Educational Development Center (EDC) has a wealth of resources available online, including lesson planning templates, lists of instructional strategies to increase accessibility, and other valuable links. (<http://www2.edc.org/accessmath/resources/links.asp>).



Encourage the development of a powerful mathematics classroom

- Encourage teachers and students to make real-world and culturally relevant connections to mathematics. Whenever possible, teachers should utilize data and graphs in the classroom setting. Students should be asked to consider ways that mathematics principles are used in the real world.
- Abstract ideas can be made more concrete with the use of manipulatives. Be sure that older students as well as students in the early grades have the opportunity to use manipulatives. Be sure that all instructional settings have access to the tools of mathematics: manipulatives, measuring tools, and technology (calculators, computers including software, Calculator-Based Learning, etc.).
- Make communicating about mathematics a regular classroom activity. Allowing students the opportunity to share ideas (and confusions) helps them to learn and develop their own mathematical thinking. Be sure students learn to justify answers and communicate their ideas. If students are hesitant to share, utilize “partner talk” or “think-pair-share” strategies.
- Make writing a part of mathematics learning. Encouraging students to keep a mathematics journal will allow them to develop metacognitive skills important to mathematical thinking. After mathematics discussions, have students write various prompts such as “Today I learned...” or “I’m still not sure about...” This practice also allows teachers to assess students’ understanding of lessons and growth over time.
- Help students develop mathematical persistence. Students should feel empowered to use a variety of strategies to solve problems rather than becoming frustrated when reliance on memorized rules or procedures is not effective. Teachers can encourage this kind of thinking by modeling a variety of solution strategies that equip students to see, understand, and use multiple solution methods.

- Be sure students are learning with understanding. Learning with understanding involves more than being able to produce correct answers to routine problems. Assessment should go beyond skill proficiency to assess understanding, reasoning, representation, and problem solving.
- Instruction should be based on the needs of the students. If teachers know the level of their students' thinking and understand how it fits within the structure of mathematics, they can design appropriate instruction and ask a variety of questions that help to scaffold students' learning.

Partner with parents

Ongoing parental involvement provides a solid foundation for students' learning and attitudes about mathematics. It is important to keep parents informed and provide opportunities for them to understand the mathematics curriculum.



- Provide opportunities for parents to learn how to help their child with mathematics and understand the district mathematics curriculum. Schedule family mathematics nights for students and parents to participate in a variety of mathematics-related activities.
- Schedule opportunities for parents to learn the mathematics in order to understand the curriculum, learn the mathematics and assist their child. Provide resources for asking good questions. Address questions related to basic facts, traditional algorithms, solving problems in more than one way, changes from the way they learned mathematics as a child, and so forth.
- Publish a regular newsletter related to the school's mathematics program. Many programs provide newsletters as ancillary materials.
- Ensure that parents understand the importance of a positive attitude regarding mathematics. Parental concerns regarding mathematics may arise from their own anxiety.
- Help parents understand that struggle and persistence are important parts of learning.
- Help parents see the everyday uses of mathematics and that providing connections at home helps foster mathematical thinking.
- Provide information regarding important changes in mathematics, including use of calculators, homework, and structure of classrooms.

Resources for Improving Mathematics Performance

Publications

Information and publications can be accessed via each organization's website.

Wisconsin Department of Public Instruction, <http://dpi.wi.gov/>.

- “Adolescent Learning Toolkit” Sections II and III were developed by Wisconsin mathematics leaders and provide information and strategies to improve student learning. Pertinent mathematics information includes: lesson development, impact of student engagement in learning on achievement, instructional practices in mathematics that enhance learning, assessing mathematical understanding in the classroom, mathematics support teachers in middle and high schools, and using assessment to inform instruction. http://dpi.wi.gov/pubsales/math_2.html
- “Planning Curriculum in Mathematics” is a resource designed to help schools and districts enhance their mathematics programs by providing research on teaching and learning as well as designing curriculum, instruction, and assessment. http://dpi.wi.gov/pubsales/math_1.html
- “WKCE-CRT Assessment Framework for Mathematics” details the objectives, subskills, and grade-level descriptors for testing at grades 3 - 8 and 10. http://dpi.wi.gov/oea/wkce-crt/math_framework.html

National Council of Teachers of Mathematics (NCTM), <http://www.nctm.org/>

- “Principles and Standards for School Mathematics” outlines six principles that should guide school mathematics programs and 10 standards that propose content and process goals. (2000) <http://standards.nctm.org/>
- “Curriculum Focal Points *for Pre-Kindergarten through Grade 8 Mathematics*” details the most important mathematical topics for each grade level, comprising related ideas, concepts, skills and procedures that form the foundation for understanding and lasting learning. (2006)
- “Navigations” is a series of grade-band books with activities and materials to implement ideas from principles and standards. (2001-2007)
- “Administrator’s Guide: How to Support and Improve Mathematics Education in Your School” is a practical guide with specific actions administrators can take to support mathematics education in their schools. (2003)
- “A Family’s Guide: Fostering Your Child’s Success in Mathematics” summarizes what today’s classroom is like and offers tips on how family members can help their children have a positive attitude and enjoy math. (2004)

National Research Council and National Academies Press, <http://www.nap.edu/>

- “Helping Children Learn Mathematics” and “Adding It Up” provide comprehensive information that will guide efforts to improve school mathematics from preschool through eighth grade. (2001)
- “How Students Learn: Mathematics in the Classroom” shows how to overcome the difficulties in teaching math to generate insight and reasoning in math students. It also has illustrated suggestions for classroom activities. (2005)

Northwest Regional Educational Laboratory, <http://www.nwrel.org/index.php/>

- Peck, Julia McClintock, “Improving Adolescent Mathematics, Findings from Research” provides research specifically related to mathematics teaching and learning for adolescents. (2005)

Wisconsin Mathematics Council, <http://www.wismath.org/>

- “Wisconsin’s New Teaching Licenses in Mathematics: How Does PI-34 Affect You?” *Wisconsin Teacher of Mathematics Journal*, Fall 2002, details performance indicators and dispositions for each of the 10 teaching standards.

U.S. Department of Education,

- “Helping Your Child Learn Mathematics” offers hints and activities for parents with children in preschool through grade 5. (2005) <http://www.ed.gov/parents/academic/help/math/index.html>
- “Foundations for Success: Report of the National Mathematics Advisory Panel” contains findings and recommendations for actions needed to provide a strong mathematics education for all students in the 21st century. (2008) <http://www.ed.gov/about/bdscomm/list/mathpanel/index.html>

Web Sites

Addressing Accessibility in Math (AAM) is a project from the Education Development Center (EDC) and supported by the National Science Foundation. The goal of AAM is to make mathematics instruction more accessible to a wide range of students, particularly those with special needs, and to promote collaboration between mathematics educators and special educators. This site provides a wealth of resources, including lesson planning templates, lists of instructional strategies to increase accessibility, and other valuable links. <http://www2.edc.org/accessmath/default.asp>

Illuminations from NCTM is a free Web site that includes lesson plans, lessons, interactive applets for students, and videos, and a wide variety of Web resources for all content and process areas of mathematics at all grade bands: pre-K–2, 3–5, 6–8, and 9–12. <http://illuminations.nctm.org/>

Learning Point Associates provides research-based resources, including exemplary lessons, to educators in the upper Midwest. <http://www.learningpt.org/>

National Library of Virtual Manipulatives provides Web-based tools for the teaching and learning of mathematics. Although the primary emphasis of the project is K–8 mathematics, many tools are effective throughout secondary and early college-level mathematics. <http://www.matti.usu.edu/nlvm/nav/index.html>

Professional Development Events

Wisconsin Department of Public Instruction’s New Wisconsin Promise Conference: <http://dpi.wi.gov/nwp/conference.html>

Wisconsin Mathematics Council’s Annual Conference in Green Lake held the first week in May: <http://www.wismath.org/>

Wisconsin Mathematics Council Workshops: <http://www.wismath.org/>

Wisconsin Title I Association fall, spring, and parent conferences: <http://www.wt1a.com/>

Wisconsin Academy Staff Development Initiative (WASDI) Summer Academies and other professional development projects: <http://www.wasdi.org/>

PBS TeacherLine offers online professional development as well as quality professional resources: <http://teacherline.pbs.org/teacherline/welcome.cfm>