

OSPI Research Document Teaching and Learning

Problem Solving

<p>Students have four basic types of problem solving strategies:</p> <ol style="list-style-type: none"> 1) Guessing operations or numbers 2) Computation driven, focused on determining operation 3) Key words 4) Operation that seems to fit 	<p>These four strategies tend to show procedural understanding, not conceptual. Teachers need to:</p> <ul style="list-style-type: none"> Select and discuss exemplary problems and solutions; Analyze solution steps; Label process; Reflect and discuss alternate solutions.
<p>Kids tend to approach problems solving procedurally, not conceptually.</p>	<p>Therefore, teachers need to provide a broad range of problems and types of problems. Problems need to be modeled using manipulatives, diagrams, drawings (clearly labeled).</p>
<p>We need to provoke discussions with our kids.</p>	<p>Ask questions about strategies, discuss reasonableness of solutions</p>
<p>Spatial ability is correlated to problem solving ability.</p>	<p>Geometry needs to be integrated early in and throughout year.</p>

Changes in Teaching and Learning

<p>Teachers and students share same misunderstandings.</p>	<p>Training and education needed to resolve misunderstanding. More time needed for instruction. Relaxed learning environment promotes learning.</p>
<p>Continuous professional development</p>	<p>Needs to extend over period of time. Study/know research with focus on classroom application. Frequent dialogue that includes feedback, reflection, support, etc.</p>
<p>Teachers change personal belief systems</p>	<p>New views of self: Occupational identity Sense of competency Self-concept as a teacher</p>
<p>Knowledge of students understanding of math</p>	<p>Build on students' thinking about math. Teachers need to engage in analytic reflection on their practice.</p>
<p>Staff collegiality</p>	<p>Dialogue frequently, use classroom observations, and peer coaching.</p>

OSPI Research Document Changes in Teaching, cont.

Students in reform oriented curriculum perform better on assessments of understanding, less well on computation.	Need to be aware of the place of computation; the pace of introducing formalized computation; aligned assessment to a new pace of computational skills.
Teachers must be open to change.	New methods will be explored. Open to new philosophies. More willing to reflect on current practices.
Teachers need to be learners.	Participate in inservice. Enhance their confidence in mathematics – content, assessment, and instructional strategies; enjoy teaching math.

Ability Grouping

Bright students benefit from ability grouping, however overall effects may be negligible.	We need to consider how to balance this result with the NCTM equity principle.
Homogeneous grouping for math can have a positive effect on achievement if the instructional level is appropriate.	Perhaps students should be grouped homogeneously when it is appropriate.
Teachers give less instruction and more homework and seatwork to general mathematics students.	This is an argument against ability grouping and for better teacher training and support.
Teachers do not adjust their teaching for high achieving students.	Teachers should work to differentiate instruction.

Mastery of Facts and Algorithms

Students need to understand the role and goal of drill.	Make instructional goals clear to your students.
Students adapt taught algorithms or create their own methods.	Give kids time to think about procedure; if their methods fail, stop and give guidance (not the procedure).
Teach underlying concepts before working towards mastery of basic skills and procedural algorithms.	Spend more time on concept development. Drill alone does not insure mathematical understanding.
Provide a balanced program including concept development and drill.	A student who has better understanding can function efficiently.

OSPI Research Document Computing Technologies

Students who use calculators	Have higher math achievement; use other methods of computation.
Closes gap on gender issues in college algebra.	Improves understanding of negative numbers, place value, and decimals.
Computers help kids identify their own errors.	Give immediate feedback.
Computers speed learning with symbolic manipulation.	Increase speed and manipulation.
Practice with computer simulations, spreadsheets, data analysis.	Empower the student to make connections at own pace.
Computers and algebra	Students perform better on modeling, problem solving, algebraic manipulations.
Calculators do not have harmful effects, especially on calculation (in a variety of contents and grade levels).	Calculator use is positive.
Calculators encourage changing problem solving approaches, exploring ideas, checking work.	Changes role of teachers.
Helps students with poor recall of facts to be more successful.	Engages students with poor fact recall to learn the process.
Calculator used well in: algebra for basic concepts, calculus, graphing.	Graphing can be skewed with pixels.
Computers are great for teaching geometry.	Enhance view of figure in dynamic terms, improves communication
Teachers and students have better attitudes when calculators are used.	

Teaching and Learning with Manipulatives

Math achievement is increased through long-term use of manipulatives.	Concept understanding increased, creative thinking increased, anxiety decreases,
Exploratory activities and cooperative groups are important.	Classrooms are noisier, need ample time, new strategies are discovered.
Students need to reflect and talk with peers and teachers.	Time need to reflect and share. Teacher and student can evaluate their understanding. Helps students make sense of concepts.
Teachers need to be knowledgeable about using manipulatives to teach math concepts so the learning is meaningful.	Need inservice, time to talk and plan with other teachers. Teachers need to be familiar with a variety of manipulatives and models.
Teachers should not assume that student can go from concrete to abstract on their own.	Helps build bridges and guide connection between concrete and abstract.

OSPI Research Document Individual Differences

Boys are favored over girls. Boys get more attention and girls are expected to be independent and self-motivated.	Chart interactions between teacher and each gender group. Plan for girl-led activities.
Minority students are often given lower expectations and not encouraged to take advanced math courses.	Teachers need awareness of own prejudices. Need to make sure and have appropriate expectations for every student. Include multicultural curriculum that encourages minority students to continue in math studies.
ESL students tend to underachieve as a result of the language barrier.	Discuss math terms and vocabulary in a variety of ways. Distinguish between everyday language and the math language found in a problem. Incorporate native language if possible.

Constructivism

Learning	Implications
Constructivism allows student to reorganize their individual experiences to solve their problems.	Students must have opportunities to form/construct personal mathematical structures.
Teacher provides motivating environment that leads to math problems to resolve.	Teachers should provide problems with real life/high interest contexts.
Scaffolding provides “just enough” support to accomplish the tasks.	Teachers need to assess students’ mathematical understanding to provide scaffolding that meets individual needs and levels.
“Close listening” is required to assess math understanding.	Time needs to be organized to facilitate one-on-one opportunities.

Performance-based Assessment

Learnings	Implications
Secondary students learn more with open-ended problems.	Prior experience, group processing skills, time needed.
Students use own assessment as a learning tool.	Students must be taught how to analyze.
Teachers adjust their teaching and curricula to meet enforced assessment requirements.	Teachers need training. Burnout and stress a factor.
Teachers need to use open-ended problems.	Need good problems, rubrics.

OSPI Research Document Culture of the Math Classroom

Students are encouraged to engage and interact with the conceptual aspects of math.	Go beyond text; learn to integrate concepts for meaningful activities.
Maintain student engagement.	Select appropriate tasks for students; proactively support students' activities; concentrate on understanding rather than the final answer. Allow appropriate amount of time; do not reduce complexity/cognitive demands of a task.
Become better problem solvers and expert thinkers.	Working in small, cooperative learning groups.
Warm and supportive teacher more effective.	Positive teachers a must.
Structure a classroom where norm is helping one's peers to learn.	Promote cooperative learning to engage students of different ability levels and increase positive attitude towards math.
Engage students to promote questioning, collaboration, explanation, and other verbalization.	Maximize small learning groups.
Build and sustain mathematical discourse.	Create personal relationship with mathematics.

Research Ideas for the Classroom Cognition and Affect

Early Years – Cognition

Students enter school with an informal knowledge of math	Students need to be nurtured. Teachers need to access prior knowledge
Students move through definite developmental stages	Curriculum needs to address these stages.
Teachers need to bridge the gap from informal to formal	Teachers need a variety of informal assessment tools.
Teachers need to encourage “talking math.”	Non-judgmental atmosphere needed for diverse thinking.
Teacher need to guide students how to internalize formal math.	Students need time and opportunity to re-invent formal math.
Teachers need to evaluate error for patterns.	Teachers should emphasize process.

Middle Years – Student Thinking

Learnings	Implications
Student must store new knowledge with prior related knowledge.	Base instruction on kids’ prior knowledge and inventory this knowledge.
Middle grade kids are either in the concrete operational, formal operational stage, or moving between.	Instruction needs to be modified for kids still at a concrete level.
Kids need constant reminders of where new information fits into overall learning.	Incorporate previously learned information into current learning (build, spiral).
Kids need time to develop concepts.	Teach underlying concepts prior to procedures.
Must understand that kids need to cognitively store information in orderly fashion.	Instruction needs to facilitate categorization of concepts.

Research Ideas for the Classroom

High School - Cognition

Metacognition is important (awareness of thinking habits).	Teach concepts, not procedures.
Effective learning will promote understanding of concepts, relationships and processes. Students help construct their own understanding.	Flexibility in procedures.
Connections with previous knowledge are important.	Developing a belief in parents, students and teachers that each student can learn new concepts and be successful (math is not genetic!)
More depth needed.	Curriculum supports problem solving in a variety of ways and helps students know what good problem solving skills are.
Viewing cognitive abilities as a set of skills that can be expanded and enriched. Students are learning to be learners.	Reasonable class size, reasonable amount of material to be presented, reasonable technology and manipulatives available.
Development of good problem solving skills is key – knowing what a good problem solver looks like.	Curriculum makes/helps connections with previous knowledge.

Research Ideas for the Classroom

Early Childhood – Affect

Student attitudes and self concept effect ability to attempt and learn math.	Positive teacher feedback with specific examples needed. Set realistic goals.
Students experience math anxiety.	Classroom should be positive and supportive.
Students believe math ability and not effort is important.	Reward students for effort and progress. Help students be persistent and motivated.
When teachers enjoy math, students are motivated to learn.	Make math fun and use concrete models and discovery lessons.
Model problem solving.	(same)
Show how math is useful.	(same)
Provide successful experiences.	(same)
Prevent learned helplessness.	(same)
Peer models and cooperative learning	(same)
Treat mistakes as normal.	Need time to gain knowledge, plan, gather and make, implement, and evaluate/reflect.

Research Ideas for the Classroom
Early Years
Teaching and Learning

Calculators and Computers

Appropriate for supplemental learning.	Provide opportunities to: broaden math experiences, problem solve, use with manipulatives.
Collaborate	Allow time to discuss and reflect.
Help students build independence in problem solving.	Provide opportunities for calculators/computers use
Understand curriculum goals and concepts	Provide time for students to explore math concepts.
Broaden math context	Select materials appropriate to curriculum and student development.
Encourage students to question.	Provide opportunities for student to question and help one another.

Problem-Solving

Understand problem solving	Experience open-ended problems without routine procedures for finding solutions, not one “right” answer.
Communicate thinking	Opportunities for kids to explain, show thinking in pictures, models, number, words.
Small group discussion – interaction	Opportunities for kid collaboration
Need concepts, reasoning skills and math vocabulary.	Provide opportunities to develop strategies.

Research Ideas for the Classroom
Early Years
Teaching and Learning

Curriculum

Due to enforced assessment, teachers may teach to the test.	Required assessment should be considered when choosing new curriculum.
Use textbooks as resource, not as “the” curriculum.	Training to build confidence in math
Teachers teach what they are familiar and comfortable with.	Even good training may not get some teachers to change behavior.
Students can’t be rushed in concept development.	Rethink scheduling and prioritize essential learnings.
Students are interested in open-ended tasks, real work situations.	Allow students time to think and work at their ability level.
Student communication enhances math learning.	Need lots of opportunities to reflect and share.

Assessment

Ask questions to explore reasoning and thinking	Use responses to guide instructional planning.
Assessment should be continuous and integrated with instruction rather than an activity separate from instruction.	Curriculum includes assessment tools that are aligned with the instruction.
Set up brief interviews.	Activities appropriate for students to do while teacher has assessment interviews.
Be a trained observer.	Teacher support and training

Research Ideas for the Classroom
Middle Years
Teaching and Learning

Models of Instruction

Humans learn best when working together.	Cooperative learning groups improve understanding and higher level thinking as well as communication.
Effective teachers stimulate students to learn math.	Must provide activities that stimulate thought, struggle, and connections.
Process is as, if not more, important than product.	Discussions, cooperative groups, etc. encourage and develop the process. Curriculum should provide scripts, etc.
Direct instruction has its place.	A balanced program is needed to incorporate direct instruction and cooperative groups.

Classroom Interactions

Request for help or clarification of procedures.	Be thoughtful – clarify where the difficulty lies, probe a bit (error analysis).
Students perceive when teachers treat students differently or when he/she is insincere.	Constantly be aware of behavior (teach and show mutual respect).
When students spend majority of time asking/answering low-level questions, they can't develop higher level thinking skills.	Need to concentrate on high level thinking skills.
Students' perception of mathematics counts.	If they think math mean rules, students wait for the rules instead of thinking – problem solving needs more experiments/investigations.
Encourage less confident students to participate more.	Provide small groups, open-ended questions.

Research Ideas for the Classroom
Middle Years
Teaching and Learning

Classroom Interactions, continued

Kinds of questions influence kinds of thinking about an answer.	Avoid yes/no questions, leading questions, whiplash questions, teacher-centered questions. Avoid labeling questions as easy/hard. Avoid knowing facial expressions. Ask high level questions.
Teachers need time to explore and learn.	Structure planning time and opportunity to collaborate such as peer coaching/observing others.
Listening to students	Informs teacher when to pose questions and when to ask for clarification and when to probe further.
Teachers act differently with students of different ability levels and gender.	Have high expectations for all students, foster autonomy.

Assessment

Learnings	Implications
Student populations are diversifying; there is evidence of inequities.	Programs must be evaluated in terms of demographics and inequities.
Student motivation might be decreased with “grade driven” assignments.	Use informal assessments (along with formal) which evaluate student knowledge.
Evaluation and assessment used for decision making and communication.	Determine use of yielded information – should determine assessment design.
Evaluation and assessment used for communication with parents.	Be sure data is understandable to audience.
Assessment data can provide means of directing student learning and making instructional decisions.	Be sure assessments are varied (tests, questions, observations, portfolios, projects) and evaluate problem solving and higher level thinking.
Assessments used to sort students	Ensure accurate decisions via varied assessments and techniques. Consider student variables such as reading level.

Research Ideas for the Classroom
High School
Teaching and Learning

Instructional Activities and Decisions

Student ability to say what he/she means arises from many opportunities to talk, explain, and discuss.	Provide opportunities for appropriate student talk in the classroom.
Cooperative learning is shown to be effective. Group goals and individual accountability important.	Well-planned cooperative learning activities should be a part of instruction.
Ability grouping often results in widening gaps in academic performance.	Be cautious about using ability groups.
Peer tutoring is beneficial for tutors and tutees.	Use peer tutors.
Math achievement increased when student used concrete instructional materials.	Use concrete instructional materials appropriately.
Teacher clarity and enthusiasm during lecture improves student achievement.	Use these elements in lectures.
When teachers wait more than 3 seconds, students give more thoughtful answers.	Increase wait time when asking questions.
Results of asking high level questions on student achievement are mixed.	More research is needed here – ask a variety of question types.
Effective demonstrations require clarity, enthusiasm, good questioning techniques, and student involvement	Include these elements in demonstrations and look for texts which give guidance for good questions and student involvement.
Effective teachers supervise practice by giving clear instructions and circulating.	Look for texts with clear instructions for concept development. Also, teachers should circulate during work time.
A completely individualized instructional approach seems not to have a positive effect on student achievement and may cause less math achievement.	Students need interaction with the teacher and their classmates – don't use completely individualized instruction.

Research Ideas for the Classroom High School Teaching and Learning

Planning and Organizing Curriculum

Communicate expectations.	Curriculum construction – get students to think and take more responsibility for their learning.
Use instructional materials to optimize instruction time	Clearly know your expectations.
Adapt instruction to student needs.	Improve/learn the ability to handle individual differences.
Address high and low level thinking.	Is tracking appropriate?
Provide regular feedback.	Need to be knowledgeable about content and teaching strategies.
Integrate instruction with other areas.	Need time to plan, work, and reflect with others and individually.
Organized environment.	Curriculum that facilitates teacher work.
Teach all students.	Flexibility, in order to adapt learning as necessary.
	Flexibility in physical environment/arrangement.

Inside the Teacher

Students learn a teacher's beliefs about math (anxiety or excitement). Every teacher influences the attitude towards math.	Be knowledgeable, excited and well trained (especially in the early years).
Students want security and structure.	Challenge students frequently to have them comfortable without security.
Students often influence teacher's views on what is needed in the class. What they desire isn't always the best.	Teachers need to look at research and facts and apply them. Also be knowledgeable about the effect of teacher expectations on each student.
The teacher is the key to application. More math knowledge means more conceptual teaching, more exploration.	Teacher training about math and about textbook and tools.
Stereotypical views of ethnicity get in our way. More interaction with boys in a class common.	Be aware of issues and give appropriate expectations. Look a text that includes multicultural information and activities.

Research Ideas for the Classroom
High School
Teaching and Learning

Evaluation

There are two types of assessment, formative and summative. Formative focuses on what and how student understands. Summative is neither continuous nor informal. It is judgmental, standards to be attained.	Text needs to include many varied typed of assessment, not just tests, but activities. Rubrics for individual student assessments.
Meaning and usefulness inferences made from test scores.	
Does a score on a test show understanding?	
Do interpretations of test results reflect social values?	
Personal relevance and individual understanding raises the question, what is acceptable standards achievement.	
Assessment should relate to student interest and real world.	

**Research Ideas for the Classroom
(Unidentified Level)
Planning and Organizing**

Controlled practice activities planned and included in every lesson.	Encourage student communication; teacher aware of student thinking; guide students as they work and process.
Cooperative groups allow all students opportunity to be actively involved.	Keep all student engaged in learning.
Textbook drill and practice not effective in developing mathematical thinking.	Use manipulatives, cooperative learning, interesting and challenging tasks.
Procedurally oriented learning is not long term (lecture/listen/homework).	Plan lessons/activities in which students engaged in projects, activities, applications, and construction; choose problems important to them.
Lesson presentation that is direct instruction should be less than ten minutes per period.	Use manipulatives, models, illustrations, model task and control practice activities to become aware of student thinking.
Select challenging and interesting tasks to promote understanding of a concept.	Students investigate and construct their own math ideas and concepts, formulate strategies for problem solving, discuss and work together.
Provide challenging activities for students who finish early.	Provide extra credit, challenging problems.
Lesson summary	Check problems, analyze, and discuss.
Middle school curriculum largely determined by textbook; limit opportunity for students to learn and understand.	Choose materials with activities and resources for development and planning; students experience problem solving, patterns and functions, algebra, statistics and probability, geometry, rational numbers.
Curriculum contains 6-7 math units per year for study.	Activity-based, concept oriented.

**Research Ideas for the Classroom
(Unidentified Level)
Teachers' Influence on the Classroom**

Stimulate and manage classroom math discourse.	Both student and teacher are clear about what is being learned.
Analyze student learning, the math task and environment.	Make ongoing instructional decision regarding goals, materials and activities.
Teacher role = moderator, consultant.	Encourage students to express their approaches.
Teachers need to have math knowledge beyond their grade level.	To eliminate misconceptions about other concepts and processes.
Teachers must contend with their own negative or positive attitude.	Negativity or enthusiasm is contagious.
Eliminate gender, race and socioeconomic status that correlate with achievement	More awareness of own biases reflects on appropriate practices.

**Classroom Organization and Models of Instruction
(Unidentified Level)**

Problems are explored based on important math ideas.	More active learning, discussion, groups, presentations, "take charge of learning."
Construct own mathematical knowledge.	Agree
Child initiated activities	Foster independence/accountabilities.
Manage flexible room arrangement.	Stimulates student thinking.
Lab oriented centers	Free exploration/growth/children's interests
Adequate time on important topics	Deep understanding, higher achievement
Lesson design (whole/part/group/whole)	Higher achievement for most (except gifted)
Math games	Higher level thinking/fun
Peer tutoring	Good for bilingual and at-risk students.