A Comparison Study*
"The Final Report of the National Mathematics Advisory Panel"
How is West Virginia Stacking Up?

National Mathematics Panel Findings	West Virginia Mathematics Initiatives
Principal Messages	
Leading societies have commanded mathematical skills that have brought them advantages in medicine and health, in technology and commerce, in navigation and exploration, in defense and finance, and in the ability to understand past failures and to forecast future developments. Success in mathematics matters to the nation at large. It matters, too, to individual students and families, because it opens doors and creates opportunities. It is yet more fundamental to recognize that the safety of the nation and the quality of life-not just the prosperity of the nation – are at issue. No longer can we accept that a rigorous mathematics education is reserved for the few who will go on to be engineers or scientists. Mathematics may indeed be "the new literacy" (Scholenfeld, 1995); at the least, it is essential for any citizen who is to be prepared for the future.	West Virginia has shown commitment to the necessity of a mathematically literate society by requiring all students take four mathematics courses for high school graduation. Policy 2510 falls short of requiring all students to take a mathematics course every year in high school.
Mathematics literacy is a serious problem in the U.S. 78% of adults cannot explain how to compute the interest paid on a loan. 71% cannot calculate the miles per gallon on a trip, and 58% cannot calculate a 10% tip for a lunch bill. 27% of 8th graders (NAEP) could not correctly shade 1/3 of a rectangle and 45% could not solve a word problem that required dividing fractions. Half of all seventeen year olds cannot read or do math at the level needed to get a job at a modern automobile plant.	West Virginia has shown commitment to improving NAEP scores. The 21st century content standards and objectives are aligned to NAEP. Although our recent NAEP scores show improvement, we are still below the national average.
The National Science Board indicates that growth of jobs in the	West Virginia's 21st Century learning initiative promises to graduate all

mathematics-intensive science and engineering workforce is outpacing overall job growth by 3:1.	students proficient in (1) rigorous core subjects and 21st century content; (2) the ability to think critically and problem solve; (3) the application of knowledge at high levels in relevant settings; (4) exhibiting personal and work place productivity skills; and in (5) the use of technology tools to assemble, communicate and analyze information. We acknowledge and focus on mathematics teaching and learning within this plan.
The sharp falloff in mathematics achievement in the U.S. begins as students reach late middle school.	This falloff in mathematics is magnified by policy makers and community members that believe our students can't do mathematics. (See "Learning Processes" – Piaget's theory has consistently been shown to be wrong). WVDE Office of Instruction – 7th grade online units, Algebra I Online Units, Geometry Online Units, K-12 Mathematics Instructional Guides and Strategies Bank all found on the Teach21 site at http://wvde.state.wv.us/teach21/
A strong grounding in high school mathematics through Algebra II or higher correlates powerfully with access to college, graduation from college, and earning in the top quartile of income from employment.	West Virginia students in the professional pathway are expected to take Algebra II and Trigonometry.
The Panel expects students to be able to proceed successfully at least through the content of Algebra II.	WV Policy 2510 does not currently support this expectation.
A commitment to "learning as we go along"…The nation should recognize there is much more to discover about how to achieve better results.	West Virginia's 21st Century learning initiative promises to graduate all students proficient in (1) rigorous core subjects and 21st century content; (2) the ability to think critically and problem solve; (3) the application of knowledge at high levels in relevant settings; (4) exhibiting personal and work place productivity skills; and in (5) the use of technology tools to assemble, communicate and analyze information. We acknowledge and focus on mathematics teaching and learning within this plan.
Curricular Content	
Any approach that continually revisits topics year after year without closure is to be avoided.	WV Mathematics Content Standards and Objectives move from topic to topic in a coherent research-based manner.
A major goal for K-8 mathematics education should be proficiency with fractions (including decimals, percents, and negative fractions), for such proficiency is foundational for algebra. (The most important foundational skill not presently developed	WV CSOs addressing fractions (including decimals, percents, and negative fractions): M.O.1.1.9, M.O.2.1.7, M.O.3.1.2, M.O.3.1.6, M.O.3.1.7, M.O.4.1.1, M.O.4.1.4, M.O.4.1.5, M.O.4.1.6, M.O.4.1.7, M.O.5.1.1, M.O.5.1.3, M.O.5.1.5, M.O. 5.1.6, M.O.5.1.7, M.O. 5.1.11,

appears to be proficiency with fractions. The teaching of fractions must be acknowledged as critically important and improved before an increase in student achievement in algebra can be expected).	M.O.6.1.4, M.O.6.1.6, M.O.6.1.8, M.O.7.1.1, M.O.7.1.5, and M.O.8.1.3. Consideration should be given to creating an "algebra readiness" diagnostic assessment that would assess conceptual understanding of fractions (including decimals, percents and negative fractions) and be administered at the end of 7th grade.
All school districts should ensure that all prepared students have access to an authentic algebra course – and should prepare more students than at the present to enroll in such a course by Grade 8.	West Virginia recommends students in the professional pathway take Algebra I in 8th grade. How do we ensure that more students than at the present enroll in such a course by Grade 8?
The Major Topics of School Algebra are: • Symbols and Expressions • Linear Equations • Quadratic Equations • Functions • Algebra of Polynomials • Combinatorics and Finite Probability	The WVDE Algebra I Online Units of Instruction were designed using the WVCSOs and are fully aligned with the National Math Panels Major Topics of School Algebra: • Unit 1: Expressions and Equations • Unit 2: Problem Solved!:--Linear Toolbox • Unit 3: Problem Solved!--Application of Linear Equations and Systems of Equations • Unit 4: A Standards-Based Approach to Polynomial Operations and Factoring Using Algebra Lab Gear • Unit 5A: Data Analysis • Unit 5B: Probability in Algebra • Unit 6: Radical and Rational Expressions • Unit 7: What if the Line Doesn't Fit? Quadratic and Exponential Functions
Learning Processes	
Use should be made of what is clearly known from rigorous research about how children learn, especially by recognizing • the advantages of children having a strong start; most children from low-income backgrounds enter school with far less knowledge that peers from middle-income backgrounds and the achievement gap in mathematical knowledge progressively widens throughout their PreK-12 years.	WVDE Office of Instruction – Elementary Mathematics Professional Development and revision of the Informal Math Assessment at http://wvde.state.wv.us/teach21/math-assessment.html Increased focus on a "strong start" in mathematics is currently underway with 50 of our best elementary mathematics teachers across the state creating model video-taped lessons across the five strands of mathematics K-5 (example of quality of lessons can be found at http://wvde.state.wv.us/professional-development/model-classrooms/science.html).
• the mutually reinforcing benefits of conceptual understanding,	See WVDE Vision Statement for the Mathematics Classroom.

procedural fluency, and automatic (i.e., quick and effortless) recall of facts;	WV Content Standards and Objectives parallel the benefits – examples include: **Conceptual Understanding** M.O.1.1.10 use concrete objects to model the addition of two or three addends and subtraction of whole numbers related to sums less than 18 and write the corresponding number sentence. M.O.2.1.12 use rounding to analyze the reasonableness of a sum or a difference. M.O.3.1.7 use concrete models and pictorial representations to demonstrate an understanding of equivalent, proper and improper fractions, and mixed numbers. **Procedural Fluency** M.O.2.1.12 create story problems that require one or two-step procedures, using a variety of strategies explain the reasoning used , justify the procedures selected and present the results. M.O.3.1.8 add and subtract 2- and 3-digit whole numbers and money with and without regrouping. M.O.4.1.8 solve multi-digit whole number multiplication problems using a variety of strategies, including the standard algorithm, justify methods used. **Automatic Recall of Facts** M.O. 1.1.12 quick recall of basic addition and subtraction facts with sums to 10 and corresponding subtraction facts. M.O.2.1.9 quick recall of basic addition facts with sums to 18 and corresponding subtraction facts. M.O.3.1.11 recall basic multiplication facts and the corresponding division facts. M.O.4.1.9 quick recall of basic multiplication facts and corresponding division facts.
• effort, not just inherent talent, counts in mathematics achievement. • Children's goals and beliefs about learning are related to their mathematics performance. • Experimental studies have shown - focus on effort increases	West Virginia's Vision Statement for the Mathematics Classroom clearly represents that effort counts see proficiency statement #5: "Engaging – Seeing mathematics as sensible, useful and doable – if you work at it – and being willing to do the work." We must work to combat the culture of low expectations. Because

students engagement in mathematics learning. • Teachers and other educational leaders should consistently help students and parents to understand that an increased emphasis on the importance of effort is related to improved mathematics performance.	mathematics instruction is not always delivered in a 21st century context, it can appear inaccessible for students. We must first believe students in West Virginia are just as capable as students across the nations before we can expect increases in performance. We know it is difficult to support that which we do not understand. We must increase efforts to educate policy makers and community members in the fact that all children can reach high levels of mathematics achievement.
The Algebra curriculum must simultaneously develop conceptual understanding, computational fluency, and problem-solving skills. Debates regarding the relative importance of these aspects of mathematical knowledge are misguided. These capabilities are mutually supportive, each facilitating learning of the others. Teachers should emphasize these interrelations; taken together, conceptual understanding of mathematical operations, fluent execution of procedures, and fast access to number combinations jointly support effective and efficient problem solving.	West Virginia's Vision Statement for the Mathematics Classroom clearly represents a balance of conceptual understanding, computational fluency and problem solving skills. The statement further defines proficiency in the mathematics classroom as described by the National Research Council: (1) Understanding – Comprehending mathematical concepts, operations and relations – knowing what mathematical symbols, diagrams and procedures mean. (2) Computing – Carrying out mathematical procedures, such as adding, subtracting, multiplying and dividing numbers flexibly, accurately, efficiently and appropriately. (3) Applying – Being able to formulate problems mathematically and to devise strategies for solving them using concepts and procedures appropriately. (4) Reasoning – Using logic to explain and justify a solution to a problem or to extend from something known to something not yet known. (5) Engaging – Seeing mathematics as sensible, useful and doable – if you work at it – and being willing to do the work.
Computational proficiency – requires fluency with the standard algorithms for addition, subtraction, multiplication and division.	WV Content Standards and Objectives include use of the standard algorithms: M.O.2.1.10 model 2- and 3-digit addition and subtraction with regrouping using multiple strategies. M.O.3.1.9 add and subtract 2- and 3-digit whole numbers and money with and without regrouping. M.O.4.1.8 solve multi-digit whole number multiplication problems

	using a variety of strategies, including the standard algorithm, justify methods used. M.O.5.1.9 solve multi-digit whole number division problems using a variety of strategies, including the standard algorithm and justify the solutions.
A conceptual understanding of fractions and decimals and the operational procedures for using them are mutually reinforcing. One key mechanism linking conceptual and procedural knowledge is the ability to represent fractions on a number line. Instruction focusing on conceptual knowledge of fractions is likely to have the broadest and largest impact on problem-solving performance when it is directed toward the accurate solution of specific problems.	WVCSOs address the conceptual understanding of fractions. See the K-12 Mathematics Instructional Guides found on the Teach21 site for specific examples (search by CSO or key word) M.O.1.1.9 identify, name, and explain why a given part is a half, third or fourth of a whole or part of a group, using concrete models. M.O.2.1.7 identify and explain fractions as part of a whole and as part of a set/group using models. M.O.3.1.5 demonstrate an understanding of fractions as part of a whole/one and as part of a set/group using models and pictorial representations. M.O.3.1.6 create concrete models and pictorial representations to compare and order fractions with like and unlike denominators, add and subtract fractions with like denominators, and verify results. M.O.3.1.7 use concrete models and pictorial representations to demonstrate an understanding of equivalent fractions, proper and improper fractions, and mixed numbers. M.O.4.1.4 using concrete models, benchmark fractions, number line • compare and order fractions with like and unlike denominators • add and subtract fractions with like and unlike denominators • model equivalent fractions model addition and subtraction of mixed numbers with and without regrouping. M.O.4.1.5 analyze the relationship of fractions to decimals using concrete objects and pictorial representations. M.O.5.1.7 analyze and solve application problems and justify reasonableness of solution in problems involving addition and subtraction of: fractions and mixed numbers, decimals. M.O.6.1.4 analyze and solve real-world problems involving addition,

	subtraction , multiplication and division of • whole numbers, • fractions, mixed numbers, • decimals, • integers, and justify the reasonableness by estimation. M.O.7.1.1 compare, order, and differentiate among integers, decimals, fractions, and irrational numbers using multiple representations (e.g., symbols, manipulatives, graphing on a number line). M.O.8.1.3 analyze and solve grade-appropriate real-world problems with whole numbers, decimals, fractions, percents, percent increase and decrease, integers, and including, but not limited to, rates, tips, discounts, sales tax and interest and verify solutions using estimation techniques.
Piaget's learning theory has been consistently shown to be wrong. A major research finding is that what is developmentally appropriate is largely contingent on prior opportunities to learn. Claims based on theories that children of particular ages cannot learn certain content because they are "too young," "not in the appropriate stage," or "not ready" have consistently been shown to be wrong. Nor are claims justified that children cannot learn particular ideas because their brains are insufficiently developed, even if they possess the prerequisite knowledge for learning the ideas.	We must work to correct widespread misconceptions in how children learn. We can no longer allow these misguided excuses to cause us to keep children from learning to their maximum potential. This kind of thinking is a big contributor of why there is a sharp drop in student achievement at the middle level.
Teachers and Teacher Education	
Research on the relationship between teachers' mathematics knowledge and students' achievement confirms the importance of teachers' content knowledge.	West Virginia has a comprehensive math achievement plan that supports continuous, extensive professional development. West Virginia's Mathematics Leadership grant is focused on teachers receiving professional development using instructional resources (units and instructional guides) to increase student achievement.
There are multiple pathways into teaching. Research indicates that differences in teachers' knowledge and effectiveness between these pathways are small or nonsignificant compared to very large differences among the performances of teachers within each pathway.	West Virginia acknowledges teacher professional development must be differentiated to improve teacher's content knowledge and pedagogy. Individual differences are addressed through use of mathematics standards-based units of instruction, instructional guides and strategy bank in mathematics professional development.

A critical component of this recommendation is that teachers be given ample opportunities to learn mathematics for teaching. Teachers must know in detail and from a more advanced perspective the mathematical content they are responsible for teaching and the connections of that content to other important mathematics, both prior to and beyond the level they are assigned to teach.	The Algebra I online units professional development is a model for learning mathematics for teaching. The WVDE mathematics plan calls for professional development in elementary mathematics, 7th grade, Algebra I, Geometry and college readiness mathematics for the fall 2008.
The Panel recommends that research be conducted on the use of full-time mathematics teachers in elementary schools.	WVDE Mathematics Plan recommends Elementary Math/Science and Reading/Social Studies specializations.
Instructional Practices	
High-quality research does not support the contention that instruction should be either entirely "student centered" or "teacher directed."	See Teach21 Mathematics Instructional Guides, Algebra Units, Geometry Units, 7th grade units for examples of balance in mathematics instructional delivery methods http://wvde.state.wv.us/teach21/ .
Teacher's regular use of formative assessment improves their students' learning, especially if teachers have additional guidance on using the assessment to design and to individualize instruction. The Panel recommends the use of formative assessment for students in the elementary grades.	WVDE has provided training on Dynamic Classroom Assessment. WVDE is providing formative assessment using Rick Stiggins, Classroom Assessment for Learning materials.
Explicit Instruction with students who have mathematical difficulties has shown consistently positive effects on performance with word problems and computation. Results are consistent for students with learning disabilities, as well as other students who perform in the lowest third of a typical class. Explicit instruction means that teachers provide clear models for solving a problem type using an array of examples, that students receive extensive practice in use of newly learned strategies and skills, that students are provided with opportunities to think aloud (i.e., talk through the decisions they make and the steps they take), and that students are provided with extensive feedback.	WVDE is working with America's Choice Mathematics Navigator to offer targeted intervention in mathematics for those struggling in mathematics. The Algebra I Support course fully aligns with the recommendation from the National Math Panel's "explicit instruction" following the tier II design of RTI. However, policy 2510 does not ensure the proper implementation and scheduling of the Algebra I Support course.
Studies show that technology-based drill and practice and tutorials can improve student performance in specific areas of mathematics. Other studies show that teaching computer programming to students can support the development of particular mathematical concepts, applications, and problem solving.	Caution is recommended when choosing computer programs for students. Conceptual understanding, computational fluency and procedural proficiency must be evident within the 21st century context of the computer instruction.

Mathematically gifted students with sufficient motivation learn mathematics faster and should be allowed to do so-a small number of studies indicate the use of an individualized program via computer instruction produces gains in learning.	This is an area we need to further explore. In a small way, we address this with the Algebra I at 8th grade recommendation. However, policy 2510 does not ensure this happens. Caution is recommended when choosing computer programs for gifted students. Conceptual understanding, computational fluency and procedural proficiency must be evident within the 21st century context of the computer instruction.
Integrated versus Single-Subject Approach The Panel finds no basis in research for preferring one or the other.	WV currently utilizes the Single-Subject Approach. WVDE fully supports the efforts of identified Math Science Partnership grants that are evaluating the effects of an Integrated Approach in several high schools.
Too many American students have a poor grasp of many core arithmetical concepts. Understanding is core to the transfer of previously learned procedures to novel problems.	WVDE employees the "Understanding by Design" framework in quality lesson designs. Understanding for transfer is at the core of the work.
Teachers should broaden instruction in computational estimation beyond rounding. Rounding is only one estimation strategy.	West Virginia Content Standards and Objectives require instruction in computational estimation beyond rounding. Examples: M.O.4.1.3 estimate solutions to problems including rounding, benchmarks, compatible numbers and evaluate the reasonableness of the solution, justify results. M.O.5.1.3 estimate solutions to problems involving whole numbers, decimals, fractions, and percents to determine reasonableness using benchmarks. M.O.6.1.4 analyze and solve real-world problems involving addition, subtraction , multiplication and division of • whole numbers, • fractions, mixed numbers, • decimals, • integers, and justify the reasonableness by estimation. M.O.7.1.5 analyze and solve grade-appropriate real-world problems with whole numbers, integers, decimals, fractions and percents including problems involving • discounts, • interest,

	• taxes, • tips, • percent increase or decrease, and justify solutions including using estimation and reasonableness. M.O.8.1.2 analyze and solve application problems with powers, squares, square roots, scientific notation, and verify solutions using estimations techniques.
Instructional Materials	
States and districts should strive for greater agreement regarding which topics will be emphasized and covered at particular grades.	WVDE, Higher Education and school districts all were involved in the development of the 21st century Mathematics Content Standards and Objectives. Agreement was also reached on the College Readiness Standards for Mathematics.
Publishers should make every effort to produce much shorter and more focused mathematics textbooks.	West Virginia is exploring the possibility of adopting only certain chapters of online textbook materials.
Assessment	
NAEP and state assessments should be improved in quality.	WESTEST 2 is being designed using our 21st Century Content Standards and Objectives.
NAEP strand on "Number Properties and Operations" should be expanded and divided into two parts. Similarly, the content of work with whole numbers and fractions on state tests should expand and cover these concepts and operations as they develop from year to year.	The content of work with whole numbers and fractions on WESTEST 2 is aligned with the WV Content Standards and Objectives. WV CSOs addressing whole numbers: M.O.K.1.1, M.O.K.1.2, M.O.K.1.3, M.O.K.1.4, M.O.K.1.5, M.O.K.1.6, M.O.K.1.8, M.O.K.1.9, M.O.K.1.10, M.O.1.1.1, M.O.1.1.2, M.O.1.1.3, M.O.1.1.4, M.O.1.1.5, M.O.1.1.6, M.O.1.1.7, M.O.1.1.8, M.O.1.1.10, M.O.1.1.11, M.O.1.1.12, M.O.1.1.13, M.O.1.1.14, M.O.2.1.1, M.O.2.1.2, M.O.2.1.3, M.O.2.1.4, M.O.2.1.5, M.O.2.1.6, M.O.2.1.8, M.O.2.1.9, M.O.2.1.10, M.O.2.1.11, M.O.2.1.12, M.O.2.1.13, M.O.3.1.1, M.O.3.1.3, M.O.3.1.4, M.O.3.1.8, M.O.3.1.9, M.O.3.1.10, M.O.3.1.11, M.O.3.1.12, M.O.3.1.13, M.O.3.1.14, M.O.4.1.1, M.O.4.1.2, M.O.4.1.3, M.O.4.1.7, M.O.4.1.8, M.O.4.1.9, M.O.4.1.10, M.O.5.1.1, M.O.5.1.2, M.O.5.1.3, M.O.5.1.4, M.O.5.1.5, M.O.5.1.8, M.O.5.1.9, M.O.5.1.10, M.O.5.1.11, M.O.6.1.1, M.O.6.1.2, M.O.6.1.3, M.O.6.1.5, M.O.6.1.8, M.O.6.1.9, M.O.7.1.1, M.O.7.1.2,

	M.O.7.1.3, M.O.7.1.5, M.O.8.1.1, M.O.8.1.2, M.O.8.1.3. WV CSOs addressing fractions (including decimals, percents, and negative fractions): M.O.1.1.9, M.O.2.1.7, M.O.3.1.2, M.O.3.1.6, M.O.3.1.7, M.O.4.1.1, M.O.4.1.4, M.O.4.1.5, M.O.4.1.6, M.O.4.1.7, M.O.5.1.1, M.O.5.1.3, M.O.5.1.5, M.O. 5.1.6, M.O.5.1.7, M.O. 5.1.11, M.O.6.1.4, M.O.6.1.6, M.O.6.1.8, M.O.7.1.1, M.O.7.1.5, and M.O.8.1.3.
Algebra problems involving patterns should be greatly reduced in tests.	WESTTEST 2 addresses the WV CSOs addressing patterns M.O.K.2.2, M.O.1.2.3, M.O.1.2.4, M.O.2.2.1, M.O.2.2.3, M.O.3.2.1, M.O.3.2.3, M.O.5.2.1, M.O.5.2.3, M.O.6.2.2, M.O.7.2.1, and M.O.8.2.7
Fractions are underrepresented on NAEP.	WESTEST 2 addresses the WV CSOs addressing fractions (including decimals, percents, and negative fractions): M.O.1.1.9, M.O.2.1.7, M.O.3.1.2, M.O.3.1.6, M.O.3.1.7, M.O.4.1.1, M.O.4.1.4, M.O.4.1.5, M.O.4.1.6, M.O.4.1.7, M.O.5.1.1, M.O.5.1.3, M.O.5.1.5, M.O. 5.1.6, M.O.5.1.7, M.O. 5.1.11, M.O.6.1.4, M.O.6.1.6, M.O.6.1.8, M.O.7.1.1, M.O.7.1.5, and M.O.8.1.3.
Calculators should not be used on test items designed to assess computational fluency.	Calculators are not used on items designed to assess computational fluency. An acceptable use policy involving use of calculators during instruction is being written by WVDE, higher education and school districts.
Research Policies and Mechanisms	
PreK-12 schools should be provided with incentives and resources to provide venues for, and encourage collaboration in, educational research.	WV continues to expand Pre-K programs and services to students and families. West Virginia has used current research to design the Universal Pre-K which will be in place by 2012.
Unnecessary barriers to research should be lowered. The resolutions of the National Board for Education Sciences concerning making individual student data available to researchers with appropriate safeguards for confidentiality should be supported.	WVDE has established an Office of Research and a partnership with REL that provides assistance from an on-site researcher.

*The official report only was used for this study. The relevant task group's subcommittee reports not included in the official report are being examined for further study.