Strategies for Enhancing Science and Mathematics in Middle Schools: The Gateway to Student Success

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Overview of Presentation

- The Research and Its Implications
  - Overview of the major research themes
- A Field Guide to Student Success in Mathematics and Science
  - Middle school reform in mathematics and science
  - Creating Strategies
- Discussion

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American Institutes for Research (AIR)

- The American Institutes for Research (AIR) is one of America's leading educational research, evaluation and consulting organizations.
- AIR provides sophisticated research, analysis, technical assistance, consulting, assessment, and strategic communications services to a wide variety of clients.
- AIR's educational research budget totals approximately $130 million a year and spans a wide variety of educational practice areas.

Overview of the Major Research Themes

Theme # 1

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U.S. Students Lagging in Globally Competitive Skills

- The mathematics and science performance of students in the American K-12 system lags substantially behind their international peers
- The 21st Century economy demands greater skills in math, science and technology
- This weakness in American student performance exists across all student groups, even among our highest performing students

Dramatic Change in the Skills Required for 21st Century Citizenship

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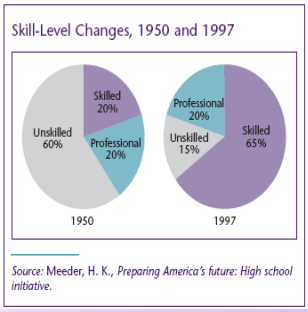

Source: Meeder, H. K., *Preparing America's future: High school initiative.*

- Over the last 50 years, the skill sets needed for the workforce has seen a dramatic shift.
- All jobs - even jobs not requiring further education after high school - necessitate higher levels of math and science skills from high school graduates.
- Between 1998 and 2008, jobs requiring STEM training will have increased by 51% - 4x faster than overall job growth.

National Tests Reveal Low Levels of Proficiency in Math and Science

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Percentage of Students At or Above Proficiency on 2005 NAEP

	Math	Science
4th	36%	29%
8th	30%	29%
12th	17%*	18%

*Represents assessments results for 2000. Mathematics NAEP results for 2005 were not available at time of publication.

Source: National Center for Education Statistics, *The nation's report card: Mathematics 2000*; National Center for Education Statistics, *The nation's report card: Mathematics 2005*.

- U.S. students fare worse the longer they stay in the K-12 schools:
  - Approx 33% of 4th and 8th grade students can perform at grade level
  - By 12th grade, less than 1 in 5 students can perform at grade level
- The consequences of U.S. students' deficiencies in math and science:
  - 33% of first-year college students have to take remedial courses
  - 63% of students taking a remedial math course do not finish college

International Comparisons of U.S. Math and Science Performance

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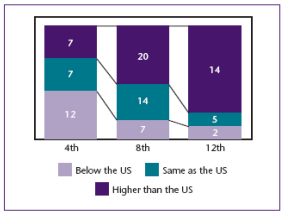
- Internationally, other countries have significantly increased their math and science proficiency and rigor when compared to U.S.
- According to TIMSS data,
  - U.S. 4th graders are performing somewhat better than the international average
  - U.S. 8th graders are performing significantly below other industrialized countries
  - By 12th grade, the U.S. is among the lowest performing countries

TIMSS Nations' Average Mathematics Performance Compared With the United States (1999)



Source: U.S. Department of Education, *Highlights from TIMSS: Overview and key findings across grade levels.*

Theme # 2

Algebra as the Key Gateway to Future Success

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- Algebra is the key "gatekeeper" for student access to the upper-level HS math and science courses
- These courses are drivers of high school graduation, college readiness and college completion

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Algebra as a Gatekeeper

- Algebra is the foundation and language system upon which higher order STEM courses are built.
- Algebra is the prerequisite course students must take before geometry, trigonometry, precalculus and calculus and science courses such as biology, chemistry and physics.
- Passing Algebra is not an end in and of itself. The key is continuing through the pipeline with upper-level courses.
- Students who pass Algebra by 9th grade are most likely to have higher achievement, continue to pass advanced math and science courses and attend and finish college.

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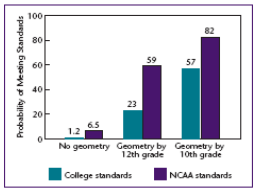
Timing of Algebra is Important

Probability of Meeting In-State College and NCAA Standards by Time Component of Taking Upper-Level Mathematics (Geometry) in High School (2002)



Source: Rodriguez, C., Borhnstedt, G., Miller, B., & Stapleton, J., *Closing the gap report: Equity 2000.*

- Passing Algebra no later than 9th grade allows time to take more advanced courses.
- While Algebra is considered the gateway course, continuing through the pipeline is the key to unlocking the effects.
- Students who passed Algebra by 9th and Geometry by 10th were:
  - 2x more likely to be ready for college than those passing Geometry by 12th grade
  - 5x more likely than those not passing Geometry at all.

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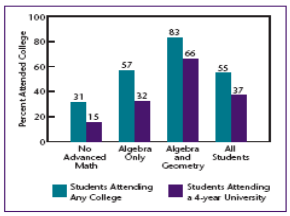
Students Passing Algebra are More Likely to Attend College

- Students passing Algebra and further upper-level math and science courses are more likely to attend college than those with no advanced math OR merely taking Algebra alone.
- Passing upper-level math and science coursework was highly correlated with finishing college and obtaining a degree.

Percentage of High School Graduates Attending College—By Algebra and Geometry Courses versus Only Algebra Courses (1999)



Source: Adelman, C., *Answers in the toolbox: Academic intensity, attendance patterns, and bachelor's degree attainment.*

Theme # 3

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Rigorous Coursework for ALL Students Helps Eliminate the Achievement Gap

- Preparing ***all*** students for rigorous math and science courses in middle school and early in HS helps to close the achievement gap among students from different ethnic and socio-economic groups

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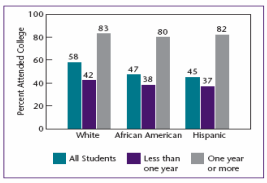
Rigorous Coursework for ALL Students Helps Eliminate the Achievement Gap

Percentage of Students from Graduating Class of 1982 Attending College Within Four Years of High School—By Race/Ethnicity and Duration of Upper-Level Coursework (1990)



Source: Pelavin, S., & Kane, M., *Changing the odds Factors increasing access to college.*

- The race, ethnicity, and SES gap in college going is all but eliminated for graduates taking at least one year of upper-level courses.
- Taking upper level coursework nearly doubled the college going rate of *all* students.

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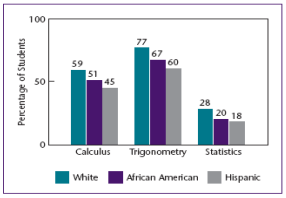
Access to Upper-level Courses Not Equal

- Minority and low-SES students take upper-level classes at half the rate as white and affluent students.
- Many minority students reported that upper-level classes were not offered at their HS.
- The key is to get students in these classes:
  - Schools that improved academic achievement focused more of student time on academic instead of "support" classes.

Percentage of 1992 12th Graders Who Attended High Schools that Offered Courses in Calculus, Trigonometry, and Statistics, by Race/Ethnicity (2006)



Source: Adelman, C. *The toolbox revisited: Paths to degree completion from high school through college.*

Middle School Reform in Mathematics and Science

Implications of the Research for Educators

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- A synthesis of the all of these research findings suggests a number of powerful implications for K-12 educators as they consider ways of improving student performance in mathematics and science.
- However, more than any other, the most compelling implication is this:
  - **If we want to dramatically increase the proportion of students graduating from high school with high-level, globally-competitive skills, then we must dramatically increase the number of students who achieve proficiency in Algebra in their middle school or early high school years.**
  - **This proficiency serves as a gateway to the advanced high school coursework that is the driver of high school graduation, college readiness and post-secondary completion rates.**

A Policy Framework for a Middle School Reform Agenda

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- Establish a fundamental goal that all students pass Algebra 1 by 9th grade.
- Require that all students take rigorous "college prep" mathematics and science courses in middle school.
- Reframe the central mission of middle schools around a goal of mathematics and science "numeracy".
- Significantly improve middle school instructional skills in mathematics and science.
- Establish a set of widely reported outcome measures that will track the performance of the K-12 system in improving student performance in mathematics and science.

What Works Best in Science & Mathematics Education Reform

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A Report on the National Science Foundation's Urban Systemic Program (2006)

- In all cases, the urban projects laid the groundwork for science and mathematics education reform by encouraging the following developments in every site:
  - **Trained the next generation of education leadership.**
  - **Improved science and mathematics course work.**
  - **Encouraged collaboration among teachers and other stakeholders.**
  - **Made instruction a priority for district leadership.**
  - **Used data to drive education decisions.**
  - **Set rigorous science and mathematics requirements.**

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What have we learned?

Pre-K-12 Design Principles - Project BEST

- Defined outcomes
- Persistence
- Personalization
- Challenging content
- Engaged adults

Connected Mathematics Project (CMP) at Michigan State University

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- CMP helps students and teachers develop understanding of important mathematical concepts, skills, procedures, and ways of thinking and reasoning, in number, geometry, measurement, algebra, probability and statistics.
- CMP is research based, and was field-tested in diverse sites across the country with approximately 45,000 students and 390 teachers.
- CMP outperforms non-CMP curricula on tests of problem-solving ability, equals or outperforms non-CMP curricula on skills tests, and promotes long term retention.
- http://connectedmath.msu.edu/

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The Overarching Goal of the Connected Mathematics Project:

- All students should be able to reason and communicate proficiently in mathematics. They should have knowledge of and skill in the use of the vocabulary, forms of representation, materials, tools, techniques, and intellectual methods of the discipline of mathematics, including the ability to define and solve problems with reason, insight, inventiveness and proficiency.

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CMP At a Glance

- Is organized around important mathematical ideas
- Develops deep understanding of important ideas
- Embeds ideas in carefully selected and sequenced problems, to develop a coherent, connected curriculum (Development of CMP)
- Makes rich connections across problems, investigations from grade to grade (Mathematics Content)
- Provides ongoing practice and assessment for important concepts, related skills, and algorithms (Components)
- Supports inquiry instruction and learning with an instructional model based on findings from recent cognitive research. (Teaching CMP)
- Supports teacher learning of both content and pedagogical strategies with extensive teacher guides (Teaching CMP)
- Meets the needs of all students to grow in their ability to reason effectively, using different representations (Differentiated Instruction)

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Why Middle School? Parallels to Other Instructional Reform Efforts

- The elementary literacy movement –
  - Core idea - Getting students to the key "gateway" of being able to read proficiently in their early grades will provide them access to a far wider array of concepts and content in the other disciplines of math, science, social studies, etc.
  - Born in the early to mid 1990's.
  - The mantra of "every child a reader by 3rd grade".
  - Student literacy has come to be seen as the central mission of elementary schools above all other academic goals.
  - We are now witnessing a sustained and significant increase in student performance in reading and writing at the elementary school level.

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Why Middle School? Parallels to Other Instructional Reform Efforts

- The high school reform movement –
  - Core idea - The traditional American high school is obsolete and there is an urgent need to dramatically increase the percentage of teenagers being prepared for rigorous post-secondary education and the challenges of a 21st century, globally competitive society.
  - Born in the early 2000's
  - The mantra of "every student college ready".
  - Central mission of high schools being re-cast around college-readiness.
  - Unclear regarding the movement's impact on student achievement.

Discussion & Task
Develop a Parallel Statement for Middle School Reform in Science and Mathematics

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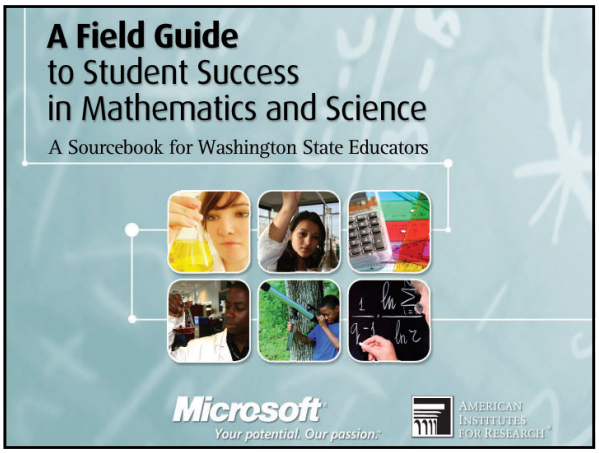
A "Movement" for Middle School Mathematics and Science

- Define and communicate a powerful central goal.
- Do not confuse the mantra with the larger goals.
- Realize that change needs to be broad and long-term.
- Maintain a central focus on instructional improvement.
- Redeploy resources.



The Gateway to Student Success in Mathematics and Science

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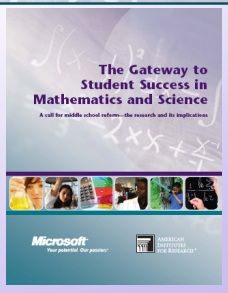
- AIR has been retained by the Microsoft Corporation to assist it in developing a philanthropic program around middle school math and science.
- In 2006, AIR completed a report entitled "The Gateway to Student Success in Mathematics and Science" which lays out the rationale and a policy framework for the initiative.
- We were then asked to create a Field Guide which is focused on best practices in middle school math and science.
- In simplest terms, the Gateway report described the "why" and the "what" of the initiative, and the Field Guide describes the "how" of math and science reform at the middle school level.



A Field Guide to Student Success in Mathematics and Science

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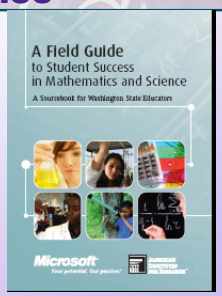
- The Field Guide is a very user friendly, practitioner-oriented sourcebook for educators.
- The Field Guide provides practitioners with a framework for school reform that is grounded in evidence from research and best practice.
- The Field Guide provides educators with concrete, actionable advice and recommendations without becoming a simplistic how-to manual.



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Primary Audience

- The primary audiences for the Field Guide are educational practitioners:
  - Superintendents
  - Central office administrators
  - Principals
  - Math/science department chairs
  - Classroom teachers

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Primary Audience

- We envision these practitioners turning to the Field Guide on a recurring basis as a helpful sourcebook to assist them in shaping math and science reform strategies in their schools and school districts.
  - Not a one-time read
  - A sourcebook for professional development and ongoing inquiry

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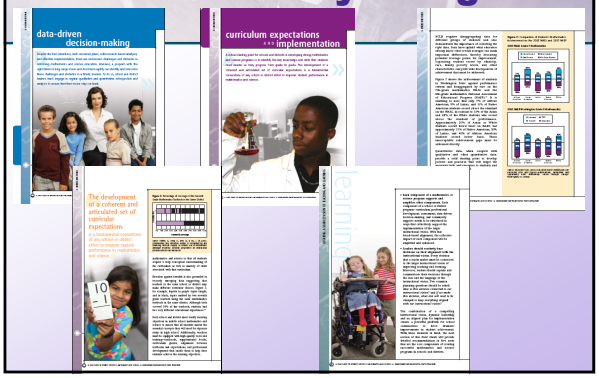
User Friendly Design



Contents of the Field Guide

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- Front Sections
  - A Message from Microsoft and AIR
  - A Call for Middle School Reform in Mathematics and Science
  - Creating a Shared Vision of Teaching and Learning
- Core Components of a Successful Mathematics and Science Program
  - Curriculum Expectations and Implementation
  - Professional Development and Professional Culture
  - Assessment
  - Data-driven Decision-making
  - Community and Stakeholder Support
- Back Sections
  - Endnotes
  - Authors

Format of Core Components

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- Description and context
  - Introduces the topic
  - Provides supporting data and resources
- District level strategies
  - To-do's for central office leaders
- School level strategies
  - To-do's for school leaders
- Reflective questions
  - Challenging questions for self and group reflection
- Summary
- Resources
  - References and research for further inquiry

Discussion & Group Activity