First Lens of International Benchmarking Report

Introduction

Ohio is a local-control state with 613 school districts and more than 300 community schools guiding 1.8 million schoolchildren in their educational journeys to adulthood. Following a decade of education reform, Ohio has demonstrated improvements in key areas, including overall student achievement and gains for disadvantaged groups.

Ohio's 2007-2008 State Report Card shows the statewide average of all students' test scores has increased by more than 25 percent since the State Report Card was introduced in 1999-2000, from 73.7 to 92.3.[1] Almost 85 percent of school districts and 70 percent of school buildings are designated as *Effective* or higher.

Ohio ranked sixth in the nation in Education Week's 2009 Quality Counts report. But when that nation is lagging far behind other countries, what does that mean for Ohio's future? Will today's students be able to compete in tomorrow's global marketplace? Can Ohio achieve a world-class educational system?

According to Achieve's report for Ohio policymakers, *Creating a world-class education system in Ohio*, "...a look at Ohio's performance relative to the U.S. – and the U.S. performance relative to the world – suggests that Ohio's students still have a large gap to close with the best in the world."

Gaps remain, with 1,351 Ohio schools and 296 Ohio districts (2007-2008 school year) failing to meet Adequate Yearly Progress (AYP) for all subgroups as defined by No Child Left Behind (NCLB). Gaps in achievement between groups of students – based on race, poverty, gender, disability and language background – continue to be one of the greatest challenges for both Ohio and the United States of America.

To compound that challenge, add the changing job market of the 21st century. If today's students are to be ready for tomorrow's jobs, Ohio must look to create an able workforce with 21st century skills in Science, Technology, Engineering and Mathematics (STEM).

In 2006, with support from the Longview Foundation, the Ohio Department of Education (ODE) convened the International Education Advisory Committee (IEAC), a group of educators, business leaders, foundation representatives, policy-makers and community organizations who believe that Ohio must plan strategically and take action to prepare students for success in the world of the 21st century. The group's mission: *To provide Ohioans with the necessary knowledge, abilities and opportunities to thrive in a global society.*

The following year, Ohio became the first state to internationally benchmark its educational system with systems around the world with a goal of ensuring that every Ohio student receives a world-class education.

[1] New tests also were phased in during this time period.

Introduction

Also in 2007, Ohio's State Board of Education created the Subcommittee for Education in the Global Economy and charged it with examining the issues surrounding the question: *"Looking ahead to 2020, what will be the most important skills, knowledge and behaviors for students to acquire to provide Ohio with competitive advantages in the global economy?"*

To answer this question, the subcommittee conducted a study from September 2007 through April 2008, which included an extensive literature review, 16 interviews with Ohio business and government leaders and an online survey. This work led to its top 10 skills necessary in the global economy.

During 2008, ODE conducted an in-depth analysis of K-8 mathematics and science standards and educational practices in Ohio compared with high-performing countries around the world.

To shape Ohio's continued growth and improvement in education, Ohio must compare its education system to the world's finest. This report takes a look at the various practices of high-performing countries and offers recommendations to keep Ohio moving forward on its continuing journey to excellence.

Specifically, this report looks at curriculum practices, social and cultural influences, and the status of the teaching profession for each of these high-performing education systems: Australia; England; Finland; Hong Kong; Ireland; Japan; The Netherlands; New Zealand; Ontario, Canada; and Singapore.

Top 10 Skills Needed
in the Global Economy*

1. Critical thinking, problem-solving skills, and applied knowledge for practical results
2. Mastery of rigorous academic content, especially in literacy, mathematics, and information technologies
3. Innovative and creative thinking, including entrepreneurial skills
4. Communication skills, both oral and written
5. Team learning and work, relationship building, and interpersonal social skills
6. Alignment of education with the needs of economic development, including better communications and cooperation between educators and business people*
7. Personal responsibility, including good work habits, work ethic, knowing how to be flexible and continue learning, and financial literacy
8. Global awareness, languages, and understanding other cultures (including history, economics and geography)
9. Communications and better interfaces between K-12 public education and post-secondary/higher education to make high school graduates better prepared for the next stages of their education and lives
10. Teacher education, preparation, and professional development to support content mastery and skill development, including applied learning (or problem-based learning) across disciplines in a global context

**Based on input from Ohio business and government stakeholders.*

As each section of this document is completed, it will be published electronically on ODE's Web site at www.education.ohio.gov, keyword search: *international benchmarking*. Additional sections will include:

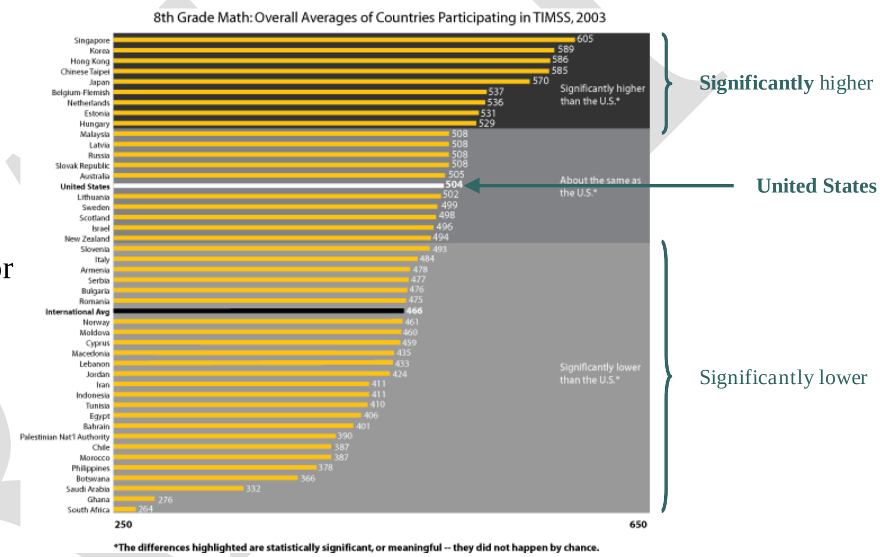
- Rationale
- First Lens: Academics
- Second Lens: Social and Cultural Influence
- Third Lens: Teaching Profession
- Conclusions/Recommendations.

Rationale

This report uses a multiple lens approach that aligns with Achieve's recommendations calling for benchmarking against multiple *systems* to account for "mutually reinforcing attributes" and to acknowledge the reality that "few (if any) of the best-performing systems are excellent on all dimensions."

Countries were selected based on persistent and statistically significant high academic achievement on the Trends in International Mathematics and Science Study (TIMSS), and/or the Program for International Student Assessment (PISA). In addition, scores from the Progress in International Reading and Literacy Study (PIRLS) were used in selecting countries to be considered for comparison in English language arts. Each country demonstrated achievement over time on one or more of these international assessments that is significantly higher than that of U.S. students in mathematics, literacy and/or science.

Significance means that the difference between the scores is statistically large enough (significant) to rule out the possibility that error or chance produced the difference.



Secondary consideration was given to countries with specific areas of strength or interest that make them valuable for comparison with Ohio, such as structural similarities, diverse demographics, uniqueness of approach to content, or success in achieving equitable achievement outcomes.

Three lenses are used to examine factors contributing to higher achievement: *Curriculum (science, mathematics and English language arts)*, *Social and Cultural Influence* and the *Status of the Teaching Profession*.

First Lens: Curriculum

- Articulated content
- Instructional delivery
- Distribution of cognitive demand on assessments

Taking a look at the first lens, written curriculum has been assessed through a comparison of the scope and sequence of Ohio's Academic Content Standards and assessments in science and mathematics against selected countries. William Schmidt's work in General Topic Trace Mapping (GTTM) of top performing nations, as identified by eighth-grade results on TIMSS, provides a framework for comparison and examines topical and grade-level areas of overlap. For a side-by-side comparison of standards in reading and literacy, eight strands developed by Achieve for the American Diploma Project were used.

In comparing systems and content, this report also looks at the cognitive aspect of learning. The revised Bloom's taxonomy specifies six cognitive process dimensions: remember, understand, apply, analyze, evaluate and create. The scoring rubric used by PISA offers similar information about student achievement levels.

Rationale, *continued*

Ohio also used the Surveys of Enacted Curriculum (SEC) to analyze the cognitive demand of its standards and assessments. SEC is a research-based tool that provides data on the alignment between the *enacted* curriculum (what is taught), the *intended* curriculum (what is required) and the *assessed* curriculum (what is tested). The SEC methodology utilizes a neutral grid that considers topic and cognitive demand. This standardizing feature provides one method for the comparison of standards and assessments across districts, states and countries.

In collaboration with the Council of Chief State School Officers (CCSSO), ODE has used the SEC to analyze Ohio's standards (benchmarks and indicators) and assessments, TIMMS and PISA assessments, and standards and assessments from high-performing countries. Ongoing analysis will provide insights on how well Ohio is aligned to international assessments, how Ohio compares from a cognitive-demand perspective, and what trends can be observed from high-performing students internationally.

Additional comparisons include review of research about classroom delivery of content and classroom culture – comprised of the interaction of content through lessons, the teacher's actions and the actions of the students.

The second lens examines social and cultural effects on the learning experience. This includes the integration of supportive services and responses to students who struggle as well as wide-ranging factors such as financial support and the organization of systems, with particular concern for the amount of decision-making at the building level.

Second Lens:
Social and Cultural Influences

- Response to Diversity
- Integration of special services
- Organizational structure of schools

How useful the educational experiences of selected countries are to Ohio depend on similarities and differences between the diversity, social fabric and culture of each country and Ohio. For instance, not every country has the same level of cultural diversity. Some countries have broader systems of social support. Therefore, this report helps identify instances where comparison countries have encountered and made progress to eliminate barriers faced by schools in Ohio and America.

Recent analysis by the Organization for Economic Co-operation and Development (OECD) examines the interaction of three systemic factors on the equity of student outcomes. Using several models to account for the variables of accountability, school autonomy and choice, it found significant interrelationship between these groupings of factors and the equity of outcomes in science and mathematics. According to Schütz, West and Woßmann:

> *The main empirical result is that rather than harming disadvantaged students, accountability, autonomy and choice appear to be tides that lift all boats.*

This study draws on factors identified through OECD's work to examine Ohio and the comparison countries. Homogeneity of the population in each country is noted, with a particular focus on identifying those countries that excel in reaching students across language or cultural barriers. The expenditure of each country on education at pre-school, K-12 (or equivalent) and postsecondary levels is reported.

Rationale, *continued*

The third lens comparison assesses factors that impact teacher effect, as indicated by recruitment, training, professional development and compensation. While studies have produced ambiguous results regarding the size and specifics of differences that define "teacher effect," there is evidence that individual teachers have varying effects on student achievement. This effect may even outweigh the effect of individual schools, particularly in mathematics, which suggests that policy to improve teaching practice is at least as important as school improvement efforts.

Third Lens:
Teaching Profession

- Recruitment
- Training
- Professional Development
- Compensation

Selection of Countries

The following countries' mathematics, literacy and/or science data were studied as indicated.

Australia – Science; Australian Territories – Literacy: Australia tests consistently and significantly higher than the U.S on PISA and at or slightly below the U.S. on TIMSS. Gaps in fourth- and eighth-grade TIMSS tests have narrowed between the lowest and highest proficiency levels with gains typically occurring at the lower end in 2003 as compared to 1995. New South Wales, Australian Central Territory and Victoria were the three top performing states/territories in literacy, according to the 2008 National Report on Schooling in Australia. Australia's teaching patterns use inquiry-based practical activities coupled with an emphasis on evidence to develop ideas and coherent content storylines. Australia also has been examining its education system to institute changes that would lead to improved student performance. Science education has been included in Australia's Science Policy, with governmental support that fosters foundation skills in science, mathematics and technology; has boosted science mathematics and technology teaching; and encourages a standardized approach to a high-quality, online science curriculum.

England – Mathematics and Science: Individually or as part of the United Kingdom, England shows instances over time of significantly outscoring the U.S. on international assessments. This includes fourth-grade mathematics as measured on TIMSS in 2003 and eighth-grade science on TIMSS in 1999 and 2003. PISA scores report England within the United Kingdom significantly above the U.S. in science for 2000 and 2006 and in mathematics in 2006.

While absolute performance is somewhat spotty compared to some of the other countries selected for comparison, England offers a recent history of education reform that may be instructive. England has worked to improve teacher recruitment and standards. The implementation of Education Action Zones sought to create empowered communities to support education services. This trajectory of reform appears to have resulted in improvement over time that is relevant to Ohio's planning efforts.

Finland – Literacy, Mathematics and Science: In literacy, Finland outperformed all other countries on the PISA in 2004 and 2008. In mathematics, the PISA 2006 results position Finland equivalent to only three other countries (Chinese Taipei, Hong Kong and Korea) in mathematics and statistically significantly higher than all other tested countries. In science, Finland outscored all other countries by a statistically significant margin. This high performance on PISA is a trend that has held steady over several test administrations.

Rationale, *continued*

An additional factor for consideration is Finland's demonstration of a high degree of equity in the outcomes of its educational system. While on average, among countries participating in PISA, 14.4 percent of the variance in student performance in science is explained by socio-economic factors, in Finland, only 8.3 percent of variance is attributable to socio-economic factors. By comparison, in the U.S., 19.9 percent of variance is linked to socio-economic factors. This has important ramifications for Ohio in terms of understanding and mitigating achievement gaps based on socio-economic status.

Hong Kong – Literacy, Mathematics and Science:

When assessed in English literacy on the PISA, Hong Kong students consistently score among the highest internationally. Hong Kong has a literacy curriculum design for its mother tongue as well as English. Students are prepared to be biliterate and trilingual. PISA 2006 data show Hong Kong to be better than most of the world in both science and mathematics. This also is the case in mathematics at the eighth-grade level as measured in TIMSS, reflecting consistently high scale scores in TIMSS mathematics over time.

Improvement in science achievement has been demonstrated concurrent with a reform program instituted in 2000 to prepare students for a knowledge-based economy in the 21st century. The recent history of reform and improvement in science is of particular interest as Ohio seeks to improve achievement.

Ireland – Literacy: Based on 2003 PISA scores (the most recent year for which U.S. scores are available) Ireland (ranking sixth with a score of 515) measures higher than the U.S. (ranking 15th with a score of 495) in terms of literacy (language, reading, writing). This along with other studies and reports examined provide an impetus to investigate Ireland's English curriculum to improve upon Ohio's English language arts standards.

Ireland's curriculum framework calls attention to a humanistic and diversified lens on student learning and achievement. The focus of the curriculum promotes general, technical and academic skills with an emphasis on interdisciplinary and self-directed learning. Recent national initiatives promote curricular development of extensive ranges of transition to adult and working life projects. This has important ramifications for Ohio, which shares with Ireland an increasingly diverse ethnic population and inclusion of young people with special needs.

Of particular interest to Ohio is Ireland's effort to reduce course overload and overlap in the secondary Irish curriculum (junior and senior cycles) through its development of new course syllabi. The course syllabi increase quality learning engagement and offer a new range of learning strategies. Course syllabi are subjected to ongoing evaluation and revision based upon analysis, advice given by subject committees, analyses of examination results and curriculum changes at primary and post-primary senior cycle levels.

Japan – Mathematics: Fourth- and eighth-grade students from Japan outperformed U.S. students by a statistically significant amount in mathematics on TIMSS in 2003. Over time, Japan has consistently placed significantly higher despite significant gains in U.S. eighth-grade mathematics from 1995 to 2003. On the 2006 PISA, Chinese Taipei, Finland, Hong Kong and Korea outscored Japan in mathematics. This places Japan significantly above the mean in mathematics, while the U.S. is significantly below the mean.

Japan has a long history with standards-based education, with a major reform to standards implemented in 2002 and some subsequent re-examination. Former Assistant Secretary of Education Diane Ravitch has described the Japanese standards as excelling in “clarity, coherence and centrality.” Japan also is successful in sustaining a high proportion of its population in education. In Japan, the highest age at which 90 percent of the population is enrolled in formal education stands at 17. In the U.S., this same figure stands at age 16. This is despite an end to compulsory education at age 15 in Japan and at (the average age of) 17 in the U.S. Both the absolute success of the Japanese system and its focus on continuous improvement hold promise for Ohio.

The Netherlands – Mathematics: The Netherlands significantly outscored the U.S. on TIMSS fourth-grade mathematics in 1995 and 2003 and eighth-grade mathematics for 1995, 1999 and 2003. On the 2003 and 2006 PISA, the Netherlands scored within the highest group of countries, significantly above the mean.

Of particular interest in the Netherlands is its Realistic Mathematics Education (RME). This pedagogical emphasis grew out of reform initiatives in the late 1960s. Developed by Freudenthal and later by Treffers, RME stresses that mathematics problems should be presented within contexts that children understand and relate to, and that “lessons should give students the ‘guided’ opportunity to ‘re-invent’ mathematics by doing it.” Examination of this well-researched pedagogical base has value to Ohio’s efforts to improve teaching of mathematics.

New Zealand – Literacy and Science: Scores from PISA Science 2006 show New Zealand in the top tier, with only Finland and Hong Kong significantly higher. This is against a background of significantly outscoring the U.S. on PISA 2000 and 2003 in both mathematics and science.

Features of interest in New Zealand are devolution of control to individual schools in 1989 within the context of a national curriculum adopted in 1993. New Zealand’s background is bicultural. Since the early 1990s, universities have been required to undertake and disseminate research in the area of education.

Scores from PISA Literacy show New Zealand scoring in the top tier on Pisa 2003 and 2006. Features of interest in New Zealand are devolution of control to individual schools in 1989 within the context of a national curriculum adopted in 1993. Since the early 1990s, universities have been required to undertake and disseminate research in the area of education. New Zealand’s curriculum reflects the diversity of its multicultural population. For educators in both New Zealand and the United States, the need to plan programs that are relevant and meaningful to all students is crucial.

Ontario, Canada – Science; Canadian Provinces – Literacy: International comparative scores are typically available only by country. As a country, Canada recently scored near the top (bested only by Finland and Hong Kong) in PISA science, and at the top of a group of only five (including Taipei, Estonia, Japan and New Zealand) with equivalent scores. In addition, Canada scored in the top five on the last three PISA administrations. Canada, like the U.S., is a federal system, with primary decision-making regarding funding, standards, evaluation and planning for education carried out by provincial ministries. Also like the U.S., the provinces vary in the amount of control vested at the local level. Ontario, like Ohio, requires schools to use province-wide assessment scores to guide improvement plans.

As a Canadian province, Ontario faces some problems that bear a striking similarity to those faced by Ohio. The ability to enact reforms is affected by divergent concerns of stakeholder groups. After many years of educational reforms, attitudes of stakeholder groups have solidified in Ontario making meaningful discussion among them more difficult. Most tend to adopt relatively hard positions about new policies and come to the table with preset positions unlikely to change as a result of direct debate.

Rationale, *continued*

Constituency groups represent the views of teachers alienated by the pace and content of reform; parents of students attending publicly funded Catholic schools; non-Catholic parents desiring similar governmental funding for attendance at other private schools; public school parents wishing to protect funding from any further splintering of public dollars; Libertarians opposing governmental control of education on principle; and parents of students already enrolled in private schools desirous of recouping their expense as a tax break. In addition, Ontario is home to a French-speaking minority (4.5 percent of the population) geographically distributed amongst the English-speaking majority population. This population faces concerns about the "marginalization and erosion of their linguistic and cultural space."

Singapore –Mathematics and Science: Singapore has long bested the U.S. by significant margins on multiple indicators, including TIMSS eighth-grade science and fourth- and eighth-grade mathematics from 1995 through 2003. In addition, Singapore significantly outscored the U.S. in fourth-grade science in 2003, the most recent year for which data are available. This success reflects educational reforms instituted since disappointing results were noted on the Second International Science Study in the mid 1980s.

While neither the stakeholders nor the responses are identical to those in Ohio, what is similar is diversity, school choice concerns and the need to balance top-down and bottom-up reform. Of further interest to Ohio are Singapore's bilingual population and instruction, and the high achievement rates for minorities. These considerations have impacted the movement toward standards and accountability as introduced by the Ministry of Education, beginning with The Common Curriculum in 1995.

First Lens – Science

Selection of Countries: The national science standards of England, Finland, Hong Kong, Australia, New Zealand and Ontario, Canada, were compared to Ohio's Academic Content Standards in Science. These governments were selected based on:

- Student performance on fourth- and eighth-grade TIMSS Science 2003 and PISA 2006;
- Discernable trends from existing TIMSS and PISA testing cycles; and
- The availability of information in English on each country's national science standards.

Only written documents prepared by the respective country's national department of education and made available via the Internet were examined.

Students in each of the selected countries significantly outperformed the U.S. on the latest international tests (TIMSS 2003 and PISA 2006). Other top performing countries were not selected for a variety of reasons. For example, Japan and Korea both showed declines for low-performing students; other countries showed mixed results between the two tests or performed comparably to the U.S. on either TIMSS or PISA.

Content Comparison: The analysis of the standards of selected countries was based on the work of William Schmidt and the staff of the Center for Research in Mathematics and Science Instruction, Center for the Study of Curriculum, Michigan State University. It incorporated 37 topics developed by Schmidt (eight in earth science, 12 in life science, 17 in physical science). The analysis was limited to grades K-8 because a number of countries place students after grade 8 in diverging tracks leading to careers or higher education.

The standards at each grade level were compared and recorded in tables and charts. The primary materials, tables and charts were examined in combination to provide general observations about the similarities and differences in the science content intended to be covered in each country. In depth exploration of content, patterns of progression or specific content at grade level was not always clear.

General Observations

Content: The majority of countries have a theme or strand type of organization for their standards, limited verbs in the curriculum statements, and a pattern of progression with a strand or theme that illustrates what can be expected of students entering a particular grade as well as what the student should learn and be able to do in successive years. Where Ohio has separate standards for process skills, most countries integrate these into their content standards.

Findings

- Ohio's standards and benchmarks are aligned with those of other countries as well as National Education Science Standards.
- There are too many topics covered by Ohio indicators and these need to be eliminated.
- Organizing science standards by themes and learning progressions will provide a way to provide coherence.
- Process standards incorporated into content standards is an effective and efficient way of addressing the standards and leads to consolidation.
- Standards documents can be concise if they are thought out well and accompanied by supplementary material that clarifies what needs to be taught at each grade.

First Lens – Science, *continued*

Teaching Strategies: Student-centered learning and scientific thinking are emphasized in much of the material on standards from the countries examined. Observation of the natural world is used to promote the idea that science is everywhere. Research using real-world data is encouraged. Communication as an integral part of science education is emphasized for promoting scientific literacy and the ability to understand science to make informed decisions as citizens. Inquiry also is emphasized, if not required, though it may be called a number of different terms, including investigative learning and real-world problem-solving.

Collaborative learning teams for teachers are common and an important teaching strategy in many of the countries. Teachers are responsible for building relationships between the classroom, the parents and the community so that students are supported in their education. Teachers also are responsible for developing community relationships that lead to involving local businesses, industries, scientists and engineers in the classroom (beyond the "career talk"), connecting students to science in the real world and incorporating work-related learning.

This table illustrates the process that was used by members of the Curriculum and Instruction Science Team when examining the available documentation on national standards from the comparison countries and the province of Ontario. Ohio's indicators were used for the analysis. Other countries appear to have more continuity in both topic presentation and grade involvement.

	K	1	2	3	4	5	6	7	8
Ohio	No Related Topics Found	Explain that living things cause changes on Earth.	No Related Topics Found	Describe Earth's resources including rocks, soil, water, air, animals and plants and the ways in which they can be conserved.	No Related Topics Found		Identify that the lithosphere contains rocks and minerals and that minerals make up rocks. Describe how rocks and minerals are formed and/or classified.	No Related Topics Found	
Singapore	No Related Topics Found								
Hong Kong	No Related Topics Found							To understand that Earth's crust is a useful source of minerals	
Ontario	No Related Topics Found			Soils in the Environment - Components of soil, comparing soils, moisture in soil, erosion of Earth materials, soil experiments	Rocks, Minerals and Erosion, classify and describe rocks, minerals, 3 classes of rocks, identify rocks from local area, effects of wind, water, and ice on rocks, soil comes from rocks, rocks describe Earth's history. Demonstrate an understanding of the physical properties of rocks and minerals			The Earth's Crust, identify rock and mineral formation, rock cycle, identify geological processes involved in rock and mineral, soil formation, classify rocks and minerals, understand their composition	No Related Topics Found
Finland	No Related Topics Found					Know how to classify substances from soil, know the chemical symbols for elements in soil, and know how to use various methods of separation of soil.		No Related Topics Found	
England	No Related Topics Found		Describe and group rocks and soils on the basis of their characteristics, appearance, texture, and permeability.			Formation of rocks by processes that take place over different timescales, mode of formation determines their texture and the minerals they contain. Rock cycle.			
New Zealand	No Related Topics Found								Understand the cyclic nature of Plate Tectonics and use this to interpret New Zealand's geological history.

First Lens – Science, *continued*

The concept and applications of Chemical Changes are found in Ohio's Academic Content Standards in the indicators for grades 1, 4, 6 and 7. Most other countries teach this topic across multiple grades, providing continuity, with Australia, England, Finland, Hong Kong and Singapore teaching the topic in grades 1-4 and grades 7-8.

PHYSICAL SCIENCES								
Chemical Changes								
	Grade							
	1	2	3	4	5	6	7	8
Ohio	●			●		●	●	
Finland	●	●	●	●			●	●
Singapore				●	●	●	●	●
Hong Kong	●	●	●	●	●	●	●	●
England	●	●	●	●	●			
Australia	●	●	●	●	●			
New Zealand								
Ontario		●			●		●	

In this representation, Ontario appears similar to Ohio where chemical changes are taught in grades 2, 5 and 7. However, this is primarily due to Schmidt's organization of the topics. Ontario's standards are arranged around strands that cover multiple topics. Within each strand there is an established pattern of progression in the coverage of topics that provide guidance for teachers. For example:

Ontario Strand: Matter and Material

- Grade 1: Characteristics of Objects and Properties of Matter
- Grade 2: Properties of Liquids and Solids
- Grade 3: Magnetic and Charged Materials
- Grade 4: Materials that Transmit, Reflect or Absorb Light of Sound
- Grade 5: Properties and Changes in Matter
- Grade 6: Properties of Air and Characteristics of Flight
- Grade 7: Pure Substances and Mixtures
- Grade 8: Fluids

Indeed, chemical changes are covered in grades 2, 5 and 7, but they are covered as part of the larger topics of Properties of Liquids and Solids, Properties and Changes in Matter, and Pure Substances and Mixtures.

Patterns of progression are not explicit in the Ohio Academic Content Standards, leading to disconnected topic presentations. Teachers rely on indicators rather than focusing on themes that span grade bands and are developed in greater depth and breadth over years.

For each topic listed, grades of topics for Ontario's curriculum relate to the Life Systems strand in a logical way as part of the intended progression:

Ontario's Strand of Life Systems

- Grade 1: Characteristics and Needs of Living Things
- Grade 2: Growth and Changes in Animals
- Grade 3: Growth and Changes in Plants
- Grade 4: Habitats and Communities
- Grade 5: Human Organ Systems
- Grade 6: Diversity of Living Things
- Grade 7: Interactions within Ecosystems
- Grade 8: Cells, Tissues, Organs and Systems

In contrast, Ohio's organizers for Life Sciences are more disconnected, redundant and without a clear progression:

Ohio's Organizers for Life Sciences

- Grade 1: Characteristics and Structure of Life, Diversity and Interdependence of Life
- Grade 2: Characteristics and Structure of Life, Diversity and Interdependence of Life, Heredity
- Grade 3: Diversity and Interdependence of Life, Heredity
- Grade 4: Diversity and Interdependence of Life, Heredity
- Grade 5: Diversity and Interdependence of Life
- Grade 6: Characteristics and Structure of Life, Diversity and Interdependence of Life, Heredity
- Grade 7: Characteristics and Structure of Life, Diversity and Interdependence of Life, Evolutionary Theory
- Grade 8: Evolutionary Theory, Heredity

LIFE SCIENCES[2]								
Interdependence of Life								
	Grade							
	1	2	3	4	5	6	7	8
Ohio	●	●	●	●	●	●	●	●
Finland	●	●		●	●	●	●	●
Singapore					○	○	○	○
Hong Kong				●	●	●		
England	●	●	●	●	●	●	●	●
Australia	●	●	●	●	●	●	●	●
New Zealand			●	●	●	●	●	●
Ontario			●					
Habitats and Niches								
	Grade							
	1	2	3	4	5	6	7	8
Ohio		●	●		●		●	
Finland					●	●	●	●
Singapore					○	○	○	○
Hong Kong					●	●		●
England	●	●	●	●	●	●	●	●
Australia					●	●		
New Zealand			●	●	●	●	●	●
Ontario		●	●					
Organs and Tissues								
	Grade							
	1	2	3	4	5	6	7	8
Ohio[3]						●		
Finland								
Singapore			○	○	○	○	○	○
Hong Kong							●	●
England						●	●	●
Australia							●	●
New Zealand								
Ontario					●			●

KEY:
- ● Topic is taught in these grades as determined by members of the Curriculum and Instruction Science Team as part of the analysis of current (post 2000) primary science standards documents from each country.
- ○ Topic is taught in these grades in Singapore as determined from an analysis conducted by W. Schmidt and his staff in the mid-1990s.

[2] Condensed comparisons of topics in Earth, Physical and Life Sciences selected from the work of W. Schmidt and the staff of the Center for Research in Mathematics and Science Instruction, Center for the Study of Curriculum, Michigan State University. The table illustrates the grade levels where topics are located in Ohio's Academic Content Standards and in curriculum documents from the selected countries.

[3] Ohio does not include human physiology in its standards.

First Lens – Science, *continued*

Hong Kong is another country that can be used to illustrate the use of strands or themes as an organizing mechanism for science standards. Hong Kong is also representative of most of the countries whose standards integrate science process skills with content knowledge. The diagram below[4] illustrates that the Hong Kong "central curriculum, in the form of an open and flexible framework, sets out what schools are encouraged to help students develop:

- Subject knowledge and skills as embodied in the learning targets and objectives of the six strands:
    - Scientific Investigation
    - Life and Living
    - The Material World
    - Energy and Change
    - The Earth and Beyond
    - Science, Technology, Society and Environment (STSE)
- Generic skills that are developed through learning activities – generic skills such as communication skills, creativity, critical thinking skills and problem-solving skills are accorded priority positions
- Values and attitudes – curiosity, openness to new ideas and respect for evidence are accorded priority positions." [5]

[4] Curriculum Development Council and the Hong Kong Examinations and Assessment Authority (2006), *Science Education Key Learning Area: New Senior Secondary Curriculum and Assessment Guide (Secondary 4-6)*, *Physics*, p 5. Retrieved on January 16, 2009 from: http://www.edb.gov.hk/FileManager/EN/Content_5185/phy_e.pdf.

[5] HKSAR (2002), Hong Kong *Science Education: Key Learning Area Curriculum Guide (Primary 1 – Secondary 3)*, p. iv.

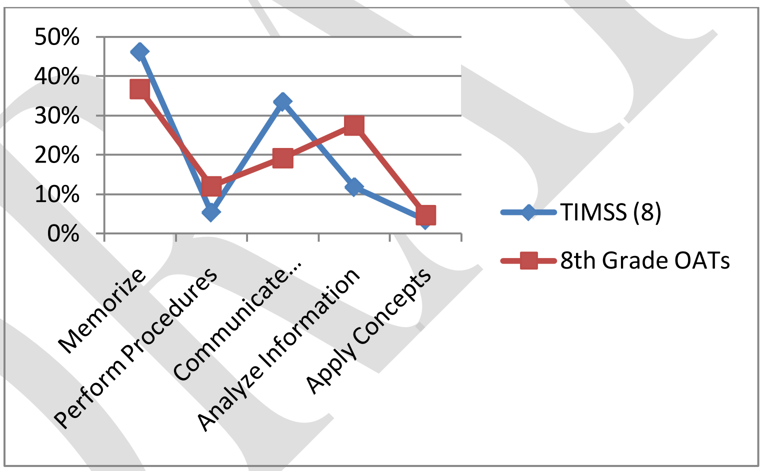
First Lens – Science, *continued*

Cognitive Depth and Alignment to International Assessments

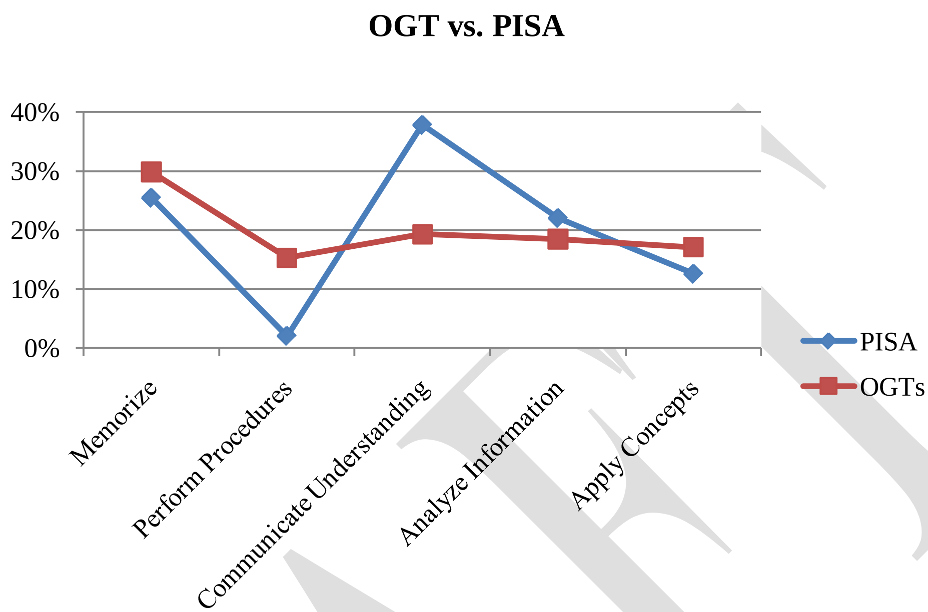
Alignment of Standards to International Assessments: Using the Survey of Enacted Curriculum (SEC) it is possible to compare the alignment of Ohio's science standards to the content tested on international tests. Two comparative factors are used. One is the alignment of topics and the other is the match of cognitive depth. The degree of alignment was then compared to that of the comparison countries. In science, Ohio is at/near the top of the pack when considering topic alignment, but drops when factoring in cognitive expectation, giving way to Singapore (4th grade) and England (8th and 9th grade), which have the highest scores in SEC alignment. Ohio's late elementary benchmarks in science rank highly in topic alignment but at/near the bottom when factoring in cognitive expectations. Clearly, at this grade span, Ohio's standards are not getting at the appropriate level of cognitive expectation.

Comparison of Ohio and International Assessments: Based on an aggregate of the 2007 and 2008 5th grade OAT (Science), Ohio was about the same as the TIMSS with regard to the level of cognitive demand. Ohio's 8th grade tests fare well in comparison to the TIMSS. Here TIMSS focuses on Communicate Understanding, while Ohio places more emphasis on Analyze Information.

8th Grade OAT (Science) vs. TIMSS (8)



At the high school level, the cognitive demand of the OGT was compared to the cognitive demand required by PISA. PISA places more emphasis on higher level skills than the OGT, which has a stronger emphasis on perform procedures. Like TIMSS, PISA places a tremendous amount of emphasis on Communicate Understanding.



Recommendations: Overall, Ohio's science standards and embedded teaching strategies compare favorably with the published standards of the countries that were investigated. The standards and benchmarks are aligned to the National Education Standards and are consistent with what was found as a result of the international benchmarking analysis of the standards of the selected countries. Although Ohio standards may be different in a few areas, no overall or significant differences were noted. However, there may be more effective ways of presenting Ohio's standards to teachers. The following recommendations are based upon the current analysis of the comparisons between the national science standards from the selected countries and Ohio's Academic Content Standards for Science.

1. Maintain but compress the standards and benchmarks (see recommendation number 6) with some slight modifications and clarification.
2. Consider a realignment of benchmarks into clearly articulated themes/strands that illustrate a progression pattern over grades and grade bands.
3. Be selective and/or limit the use of verbs in the curriculum statements of the standards and benchmarks. Verbs can inadvertently lead teachers to a specific cognitive level whereas benchmarks should be taught at all cognitive levels.
4. Eliminate the indicators and look at learning progressions that show prerequisite skills and concepts and how they build upon each other. Although not the original intent, indicators are being used as an all-inclusive checklist by teachers, resulting in broad coverage to reach all indicators rather than selecting topics to pursue in depth.
5. Introduce scientific vocabulary at the appropriate grade but teach "concept first, scientific vocabulary and definition later."
6. Eliminate the three process standards: *Technology*, *Scientific Inquiry* and *Scientific Ways of Knowing*, as separate entities and incorporate them into each of the three content standards: *Earth and Space Science,*

Physical Sciences and *Life Sciences*. As process standards cannot be taught devoid of content, science skills, as part of the content standards, will connect in a more logical way to the content areas.

7. Provide a companion document for the standards to illustrate what is meant by content progression, cognitive levels and integration of process standards, providing real-world examples and suggestions.
8. Update ODE's current Standards-Based Science Instruction and Classroom Inquiry document with regards to the Learning Cycle.

First Lens – Mathematics

Selection of Countries: The national mathematics standards of Singapore, Hong Kong, Japan, England, the Netherlands and Finland were compared to Ohio's Academic Content Standards in Mathematics. These countries were selected based on:

- Student performance on fourth- and eighth-grade TIMSS Mathematics 2003 and PISA 2006;
- Discernable trends from existing TIMSS and PISA testing cycles; and
- The availability of information in English on each country's national mathematics standards.

Only written documents prepared by the respective country's national department of education and made available via the Internet were examined. In the case of Netherlands, an official standards document was not identified, but the country was included for teaching strategies and other lenses.

Students in each of the selected Asian countries and the Netherlands have consistently and significantly outperformed the U.S. in grades 4 and 8 over several administrations of TIMSS. England significantly outperformed the U.S. on the 2003 fourth-grade TIMSS although slightly below the U.S. score for eighth grade. Finland did not participate in TIMSS but it was the top ranked country on PISA 2006.

Content Comparisons: ODE identified and analyzed appropriate standards documents for each country to develop understanding of their intent, language and, when more than one format existed, the relationship between them. To ensure accurate interpretation of the documents and the correspondence and alignment of grades and ages across countries, ODE completed background studies to understand the educational framework of the countries.

The TIMSS Mathematics Framework was chosen to organize comparisons because it is internationally recognized and accepted and because of a consensus that it would be at an appropriate "grain size." The TIMSS framework was modified slightly (e.g., eliminating high school topics) to suit a comparison for grades K-8. The analysis was limited to grades K-8 because a number of countries place students after grade 8 in diverging tracks leading to careers or higher education.

For each country and Ohio, the standards documents were analyzed and coded to the corresponding TIMSS topic. For each TIMSS topic, a spreadsheet was used as a matrix to organize the grade-band and grade-level expectations. Each row included expectations for Ohio or a comparison country. The columns represented grades K-8.

Within a TIMSS topic (e.g., common fractions), subtopics were coded with different colors (e.g.: red for *meaning and representation*; blue for *computations with fractions and mixed numbers*) to help identify similarities and differences in the organization of subtopics across grades among Ohio and the comparison countries. Completed matrices were printed on multiple sheets of paper and reassembled into a large chart for group analysis.

For each TIMSS topic, ODE mathematics staff examined the chart, sharing and recording similarities, differences and other observations between and among Ohio and the comparison countries, noting in particular the grades in which topics and subtopics were introduced, developed and completed.

First Lens – Mathematics, *continued*

General observations were recorded during the process, and overall findings were developed through analysis and synthesis of the topic-specific findings and informed by holistic understanding of the standards document and educational systems of each of the comparison countries.

Findings and General Observations

Ohio's Academic Content Standards in grades K-8 mathematics include essentially the same content as the comparison countries, but topics are spread over more years in Ohio. Thus, Ohio's standards include more topics in each grade than the comparison countries, and therefore each topic is likely to receive less instructional emphasis and depth in Ohio.

Ohio uses the same five content strands (e.g., *measurement*) from grades K through 12 with equal emphasis in assessment. In the comparison countries, the content strands vary across grades as appropriate for the grade. For example, *number* and *algebra* are often combined in the early grades. *Geometry* and *measurement* are often combined. Within a strand, emphasis in the comparison countries appears to vary across grades.

In England and Finland, the expectations are described via grade bands, making it hard to identify grade-specific expectations. Thus, the Pacific Rim countries (Japan, Hong Kong and Singapore), with their grade-specific expectations, largely drove the content comparison.

The Pacific Rim countries introduce a topic and apply that topic to solve problems in the same grade. Ohio introduces some topics earlier than comparison countries (at the level of "exposure") and sometimes postpones application of concepts until later grades. In the comparison countries, the standards suggest learning progressions in the sense that the expectations at each grade clearly build upon and move beyond what was expected at earlier grades. Ohio's standards, in contrast, suggest redundancy across grades and continuing review.

The K-8 standards in Ohio and comparison countries include quite a bit of content typically taught in Algebra 1 courses, as well as some content taught in high school geometry courses.

Cognitive Depth and Alignment to International Tests

Cognitive Demand of Assessments: The following table examines the emphasis on higher order cognitive demand expectations across several mathematics tests. This example considers the points SEC-coded Level III or higher (Demonstrate Understanding; Conjecture, Analyze, Generalize, Prove; Solve Non-Routine Novel Problems/Make Connections).

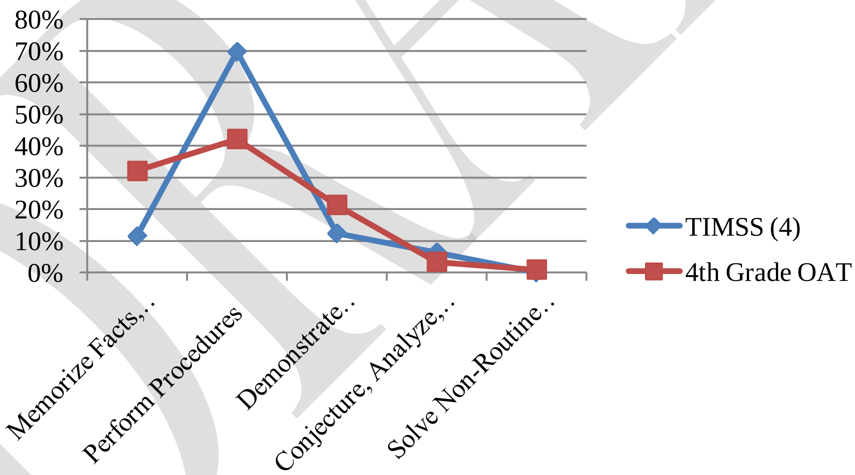
Percentage of Points Coded Level III or Higher (Math Assessments)

	4th	8th	High School
Ohio*	25.5%	22.1%	20.8%
TIMSS	18.8	19.6	
PISA			35.7
Hong Kong	12.8 (3rd grade)		13.5
Japan	50.1 (6th grade)		55.0
SAT			18.2

*Ohio scores reflect aggregate of several test forms

One major difference in these comparisons is that PISA places more emphasis on higher level expectations than the OGT. Almost 80% of the points on the OGT were coded the lower level Memorize Facts, Definitions, Formulas or Perform Procedures. Of note, the two Japanese tests (6th and 9th grade) score much higher than any of the other tests in the sample with 50.1% and 55%, respectively, of their points Level III and higher. The bulk of these points were coded at Level III: Demonstrate Understanding. While Ohio's 4th grade OATs were coded somewhat higher than the TIMSS, the Ohio tests places more emphasis on Level I: Memorizing Facts, Definitions, and Formulas than TIMSS (34% to 12%), while TIMSS places almost 70% of its emphasis on Level II: Perform Procedures.

4th Grade OAT vs. TIMSS (4)



Cognitive Demand of Math Standards: A comparison of the cognitive expectations of the various countries' standards reveals some mixed results. As shown in the table below, Ohio's math benchmarks are the highest ranked (average of 4th, 8th, High School) in terms of the percentage of points coded Level III or higher. However, the math indicators are ranked much lower behind England, Finland and Hong Kong. Ohio teachers that are focusing only on the indicators may be covering less depth of knowledge.

Proportion of Points Coded Level III or Higher (Math Standards)

	4th	**8th**	**High School (9th)**	**Average**
Ohio Benchmarks	.46	.54	.54	.51
England	.48	.34	.41	.41
Finland		.39		.39
Hong Kong	.45	.33	.33	.37
Ohio Indicators	.31	.37	.27	.32
Japan	.42	.26	.14	.27
Singapore	.20	.09	.05	.11

First Lens – Mathematics, *continued*

Example: Learning about Volume

In Ohio, the concept of volume is taught as a part of Measurement Benchmarks. It appears, along with perimeter and area, *at every grade level from 3 through 8*. It may be included again as a part of high school Geometry. In Hong Kong, each concept is developed separately, with mastery presumed after that point. Perimeter (not shown) is developed in fourth grade and then revisited as circumference in sixth grade. Area (not shown) is developed across grades 4 and 5. Volume is developed across grades 5 and 6.

Ohio Benchmarks	Grade	Ohio (Indicators)	Hong Kong
A. Select appropriate units for perimeter, area, weight, **volume** (capacity) time and temperature using related U.S. customary and metric units.	**3**	Make estimates for perimeter, area and volume.	
	4	Demonstrate and describe perimeter as surrounding and area as covering a 2D object and volume as filling a 3D object.	
A. Select appropriate units to measure angles, circumference, surface area, mass and volume using related U.S. customary and metric units. B. Convert units of length area, **volume**, mass and time within the same measurement system. C. Identify appropriate tools and apply appropriate techniques for measuring angles, perimeter or circumference and area of triangles quadrilaterals, circles and composite shapes and surface area and **volume** of prisms and cylinders. E. Use problem solving techniques and technology as needed to solve problems involving length, weight, perimeter, area, **volume** 3, time and temperature. F. Analyze and explain what happens to area and perimeter or surface area and **volume** when the dimensions of an object are changed. G. Understand and demonstrate the independence of perimeter and area for 2D and of surface area and **volume** for 3D shapes.	**5**	Demonstrate and describe the differences between covering the faces (surface area) and filling the interior (**volume**).	• Develop the concept of **volume** • Compare the **volume** of objects intuitively • Introduce the standard unit cubic cm • Measure and compare the **volume** of objects using cubic cm • Understand the need for using a unit larger than cubic cm • Recognize cubic cm and its use • Understand and apply the formula for finding the **volume** of cubes and cuboids • Find the **volume** of irregular solids
	6	Understand and describe the difference between surface area and **volume**...	• Recognize the relationship between capacity and **volume** • Find the **volume** of irregular solids by displacement of water
	7	Use strategies to develop formulas for finding... **volume** of cylinders and prisms... Describe what happens to the ... **volume** of a 3D object when the measurements of the object are changed	• Understand and use the formulas for... **volume** of cubes, cuboids, prisms and cylinders.

First Lens – Mathematics, *continued*

Recommendations

1. Eliminate the distinction between grade-band and grade-specific expectations, and focus instead on grade-specific standards, organized as a small number of topics to be taught in depth.
2. Ensure that topics develop over a few years and that the expectations at each grade clearly build upon and move beyond the expectations for previous grades.
3. Keep the standards few, clear and brief at each grade, emphasizing understanding and problem-solving alongside procedural skills.
4. Include applications of concepts when the concepts are taught.
5. Eliminate early “exposure-only” standards, so topics are expected to be used and understood when introduced.
6. Develop supporting documents that elaborate the standards, delineate learning progressions and provide instructional strategies and guidance for assessment.
7. Use the TIMSS topics as a structure for organizing the learning progressions.
8. Rather than five standards with equal assessment emphasis at each grade, consider varying the emphasis across the grades, to fit the foci of the standards for each grade.
9. A revision of the high school standards should clearly build upon and move beyond the introductory algebra and geometry that is included in the revised K-8 standards.
10. Extend the content comparisons into high school to inform standards revision there. Consider common expectations for all students through grade 10 or 11, with the goal of readiness for college and careers.

First Lens – English Language Arts

Selection of Countries: The reading and literacy standards of Australian Territories, Canadian Provinces, Finland, Hong Kong, Ireland and New Zealand were compared to Ohio's Academic Content Standards in English Language Arts (ELA). These countries were selected based on:

- Student performance on PISA 2003 and 2006;
- Discernable trends from existing PISA testing cycles;
- Commonalities and interest (e.g., similar strands, topics, secondary level frameworks); and
- The availability of information in English on each country's academic standards.

Only written documents prepared by the respective country's national department of education and made available via the Internet were examined.

Students in each of the selected countries have consistently outperformed the U.S. over several administrations of PISA. Finland served as the top performing country in 2000, 2003 and 2006. All of the selected countries participated in the 2003 and 2006 administrations.

Content Comparisons: ODE identified and analyzed appropriate standards documents for each country to develop understanding of their intent, language and, when more than one format existed, the relationship among them. To ensure accurate interpretation of documents and correspondence and alignment of grades and ages across countries, ODE completed background studies to understand the educational frameworks.

The American Diploma Project (ADP) English strands were chosen to organize comparisons because they are nationally recognized and accepted and also embrace essential English elements. The ADP strands developed to inform end of high school expectations were well suited for the ninth- to 12th-grade comparisons.

For each country and Ohio, the standards documents were analyzed and coded to the corresponding ADP strand. For each strand, grade-band and grade-level expectations were organized in a matrix with expectations for Ohio and comparison countries included by grade level.

Within an ADP strand, subtopics (e.g. strand: writing: subtopic: conventions) were used and similarities, differences and other observations were recorded. In particular, the grades and bands in which strands and subtopics were introduced, developed and completed were noted.

Findings

Content: Most of countries selected use strands or concepts to organize their standards. All of the countries include verb- driven standards statements. In addition, standard statements are often recursive and embrace a sophistication which comes from continuous implementation and complexity of texts. Process skills are integrated in the content standards. Ohio's ELA standards have separate standards for process skills, but embed the skills in the other standards as well.

Collaborative learning is present in the countries' standards expectations. This expectation is not present in Ohio's ELA standards. In addition, many of the countries' standards address a cultural and global view that is not present in Ohio's standards.

First Lens – English Language Arts

New Zealand and Ontario embed research within their writing strands rather than present it as a separate strand. New Zealand and Ontario also recognize media. Ontario recognizes media as a separate strand and New Zealand embeds it within its three strands. Like Ohio's standards, the Australian standards focus on writing, reading and communication skills, with compulsory education ending at grade 10.

Example

Strands: Ontario
- Oral Communication
- Reading and Literature
- Writing
- Media Studies

Strands: New Zealand
- Oral Language
- Written Language
- Visual Language

Recommendations: Overall, Ohio's ELA standards compare favorably with the published standards of selected countries, both organizationally and in terms of content. Although Ohio standards may be different in a few areas, no overall or significant differences in content were noted.

Ohio's standards and benchmarks are aligned to the National Council of Teachers of English (NCTE) and International Reading Association (IRA) standards.

There may be more effective ways of presenting Ohio's standards to teachers.
1. Reduce the number of standards.
2. Redesign the standards framework.
3. Infuse common 21st Century processes (collaboration, communication, critical thinking, meta-cognition, problem-solving and research).
4. Emphasize content.

Appendix – Science Exemplar

Comparison of Earth Science Topics		
Schmidt Topic and Definition	**Findings**	**Recommendations for Ohio**
Earth's Composition (1.1.1.1) *Earth's crust mantle and core; distribution of metals, minerals*	For countries that teach plate tectonics, the information for this topic may simply be imbedded. Learning about Earth's composition is essential for understanding why plates move. So this topic may be very difficult to isolate and may be a misrepresentation of what is actually taught in the classroom. It is clear that if this topic is taught, it is taught along with plate tectonics at the middle school level in all of the countries that were examined.	This is clearly a middle school topic, directly related to Plate Tectonics ("Building and Breaking" listed below). Ohio may want to limit this topic to one year at the middle school level, preceding the introduction of plate tectonics. This will help in developing a clear progression of plate tectonics in Ohio Standards.
Landforms (1.1.1.2) *Mountains, valleys, continents*	Some countries include topography, geography and general map reading along with general information regarding landforms; others include detailed information about the processes of creating or destroying land (e.g. deposition, erosion). So even though the information within the topic "Landforms" is quite different, they are together in this study.	Ohio should develop a clear progression of this topic to avoid re-teaching similar material year after year. For example: defining the landforms, then how to recognize them on a map, then learn about how they form. This topic is closely related to erosion, weathering, deposition, and plate tectonics, so the progression should be evident.
Bodies of Water (1.1.1.3) *Oceans, lakes, ponds, rivers, bottom of ocean*	There is a difference between teaching about water as a resource and understanding natural waters (such as the ocean or lakes). But again, because this is such a broad category, both headings can be found in this one topic. Certainly, it would be hoped that in teaching about the importance of water as a resource, properties and/or states of water would be included, but that information is not provided at this level. For example, England introduces states of water and water chemistry in elementary grades, but does not include natural bodies of water, so it appears from this topic list that England does not teach about water, but that is not the case.	Ohio needs to indicate a clear, concise progression for this topic to avoid repeating the same cognitive level at each grade. This topic is closely related to "Physical Cycles" (hydrologic cycle) listed below. Teachers must be able to see how introducing the basics about water must be built upon each year, so that students can see that connection as they learn new things about water each year.

APPENDIX – Mathematics Exemplar

Topic	TIMSS Definition	Findings	Recommendations
Whole Number Meaning	TIMSS definition: use of numbers, place value and numeration, ordering and comparing numbers	• Varying levels of detail exist across foreign countries. • Ohio standards fit the international consensus for building whole number meaning: **Grade** **K** **1** **2** **3** **4** **Place Value** **10s** **100s** **1000s** **10,000s** **100,000s**	
Whole Number Operations	TIMSS definition: addition, subtraction, multiplication, division, mixed operations including order of operations	• Order of operations: Ohio grade 5; England/Singapore grade 5-7; not specified in Finland, Hong Kong, or Japan. • Singapore – numeracy is the basis in all areas of P-6 program. • Introduction of the each of the four operations is consistent between Ohio and the foreign countries; however, mixed operations involving simple numbers occurs earlier in foreign countries. • Recall/memory of facts stated explicitly in most foreign country documents. • Foreign countries reinforce facts by using them in context across all standards not just as a plain computation. Foreign countries use facts in daily life context not in isolation.	
Whole Number Properties	TIMSS definition: associative properties, commutative properties, identify properties, distributive properties, other number properties	• Several countries rarely mention whole number properties whereas Ohio mentions whole number properties at most every grade. • Japan and Hong Kong begin with using properties in computation rather than knowing vocabulary. • Ohio is an outlier in including the concept of "identity" (grades 5, 8).	
Common Fractions	TIMSS definition: meaning and representation of common fractions, computations with common fractions and mixed numbers	• Ohio introduces fractions and fraction arithmetic earlier (grade 1) than in other countries (little before grade 3). • Foreign countries generally introduce meaning of fractions in grades 3-4, with fraction arithmetic in grades 5-6.	Remove fraction indicators from grades 1, 2, 7 and 8. Fractions in grades 7-8 should be embedded in proportional reasoning.
Decimal Fractions	TIMSS definition: meaning and representation of decimal fractions, computations with decimals	• Most decimals development occurs in grades 4-6. • There is not a clear pattern across the countries.	Clarify the decimals indicators to specify the developmental progression.
Relationship Between Common Fractions and Decimal Fractions	TIMSS definition: Conversion equivalent forms, ordering of fractions and decimals	• Ohio and foreign countries consistent with coverage in grades 4-7 with most work occurring in grades 5 and 6. • Ohio and Singapore omit work in grade 6.	Developmental progression: teach in a couple of grades then assume students can translate after those grades, grade 6.

APPENDIX – English Language Arts Exemplar

ENGLISH LANGUAGE ARTS IB ANALYSIS				
Strand & Topic	**Current Ohio Standards**	**International Benchmarking**		**Alignment to Achieve & ADP**
		Findings	Recommendations	
Language: Reciprocal Communication(collaboration)	Not addressed in Ohio's standards	All countries address collaboration within their reading/literacy standards and curriculum. Collaboration is either embedded or associated with a separate strand (e.g., communication). For most countries, collaboration is connected to their listening and speaking expectations.	Ohio currently does not address collaboration within any of its standards. Listening and speaking are addressed in the ELA standards, but no implicit or explicit connections are made to collaboration. Based on the findings, Ohio should develop collaboration expectations connected to listening and speaking statements within the revised standards.	Achieve 9-10/11-12 W.1.1 Speaking and Sharing in Teams and Groups W.1.2 Listening to Ideas of Others in Teams and Groups W.1.3 Working in Teams ADP **B7.** Participate productively in self-directed work teams for a particular purpose (for example, to interpret literature, write or critique a proposal, solve a problem, make a decision), including: