SCIENCE

Colorado Annual Standards Review

The STATE's Formula for Success 2006

A report on the performance of our state's science standards and recommendations for stronger science achievement.

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Colorado Department of Education

COLORADO STATE BOARD OF EDUCATION

The State's Formula for Success

A report on the performance of our state's science standards and recommendations for stronger science achievement

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COLORADO'S SCIENCE STANDARDS REVIEW

This is the second in a series of annual reviews of the Colorado Model Content Standards. Its purpose is to identify student performance over time on measures of our existing standards, identify ways to affirm and strengthen our standards and more clearly articulate the practices used by Colorado schools to make substantial gain in the achievement of students to the standards.

"Year of Science" Process

The Office of Learning and Results visited, presented and interviewed over 900 science-concerned policy, educator, media and university-based individuals. This nine-month series of study and listening, editing and asking was statewide. Research on data points and historical trend data was gathered from state and national resources, university faculty, and department staff including finance, licensure, assessment, regional managers, Title I and Information Management Services.

Timeline (2005 – 2006)

September	Compare international & national science standards with student performance
September	Examine existing Colorado student science performance data
October	Examine history of CO Standards and Frameworks in science
Sept – April	Classroom observations, and interviews statewide
Sept – April	Examine science teacher preparation, licensure, and PD
Sept – April	Share data with: State Board of Education 15 sites statewide Higher Education Groups Superintendent and principal/ BOCES state meetings Teacher groups and professional development leaders Science educator professional associations
Jan – April	Review of current research on science cognition and learning
Jan – April	Identify, survey and interview schools making gains in science
March	Analyze gaps/ needs to strengthen Colorado Science Standards & Assessment
April	Review of existing science resources
April	Convene an alignment study for initial discussion
May-Sept	Compile recommendations and work with focus groups for accuracy
June	15th Annual Standards & Assessment Conference
Fall	Board approval of any standards/frameworks changes

NATIONAL OVERVIEW OF K-12 SCIENCE

The United States' student performance in the sciences has become a national topic for concern. For a nation that demands economic competitiveness, the outlook will become ever more pessimistic if science continues to be third class in the American education system.

TIMSS (Trends in International Math and Science Study) 2003 is an international comparison of mathematics and science achievement in the primary and middle grades. The assessment is based on common aspects of curricula and assessment performance from all participating countries. In the eighth grade, the US ranked 16th out of 17 industrialized nations that participated in 2003.

The United States does not have a mandatory national standard for science performance. Our national science standards are merely suggestions as individual states dictate their own bottom line for student performance. Nevertheless, one voluntary national exam, administered every other year for decades does exist: the National Assessment for Educational Progress. Science results for 2003 indicate that overall proficiency in science is surprisingly low. At fourth grade, 29% are functioning at the grade level expected for that age. At eighth grade, proficiency increased a mere 3% over 2000 test data, with only 34% of our nation's students scoring proficient or above. Twelfth graders stand at 21% proficient on the national science proficiency test. (NAEP, 2000)

Additionally, substantial performance gaps occur with specific minority groups in science at all grades tested, especially for African-American students. (NCES, 2003). At each grade level, white and Asian-American students outperform African-American, Hispanic and Indian/Alaska Native students (The Nation's Report Card: Science Highlights 2001-2003).

PISA's (Program for International Student Achievement) 2003 international mathematics and science assessment given to 15 year old students in 29 countries measures the 'yield' of a nation's education system. One part of PISA is specifically designed to determine overall competencies students have acquired to apply scientific literacy knowledge and skills to problems with real-world contexts. The PISA science scale score for 29 participating countries is 500. The United States score in 2003 was 401. This ranked the United States 24th out of 29 participating countries (PISA, 2003).

Despite years of National Science Foundation funding and recent popular press attention, America's schools are not producing even half of their students at grade-level science achievement. Unfortunately, to no surprise, high schools are also not graduating increased numbers of students who indicate an interest in further science education (NSF, 2005).

COLORADO SCIENCE STANDARDS

The Colorado State Board of Education adopted Colorado's Model Content Science Standards in 1995. The assessment frameworks, which articulate each science topic that students are expected to know on the 8th grade CSAP were built in 2003. The state science test was expanded to measure fifth, eighth, and tenth grade performance in 2006.

The Colorado Model Content Science Standards were developed by a group of experienced Colorado science educators and revised through public meetings and written reviews conducted in 1994. The "Benchmarks" from the American Association for the Advancement of Science's "Project 2061" and draft reports from the National Science Education Standards Project at the National Research Council were used as references in the development of these standards. See the appendix for a complete list of the 1995 Colorado Model Content Science Standards Taskforce.

The numerical order of the six science content standards does not imply any particular judgments regarding their relative importance or teaching priorities. In fact, Standards 1, 5, and 6 – relating to scientific investigations, applications, and connections – should be addressed directly, as well as with teacher guided inquiry methods in subject matter from the physical, life, and earth/space sciences (Standards 2, 3, and 4). Even though the six science content standards are identified separately, they represent interconnected expectations for students.

No state science curriculum exists in Colorado, as it is a locally controlled state.

No state science curriculum exists in Colorado, as it is a locally controlled state. Textbooks, curriculum decisions and supplemental resources are decided and purchased at a local district level. In addition, at the local level, individual schools and districts determine when a science topic is introduced or offered. Therefore, physical and earth science classes are present in different grades in different cities.

Various American educational institutions have rated and ranked individual states' standards and performance based on a host of variable conditions. The Fordham Foundation rates science standards based on state curriculum benchmarks. Fordham evaluated and graded Colorado standards by looking at both the standards and the assessment frameworks with an eye for seriousness, evolution, content, organization and inquiry. Colorado was issued a "B". *Education Week* evaluates states' science standards based on clarity and alignment. Colorado was given a "B" for its quality science standards, alignment of standards to the state assessment and for rigor.

SCIENCE ACHIEVEMENT IN COLORADO

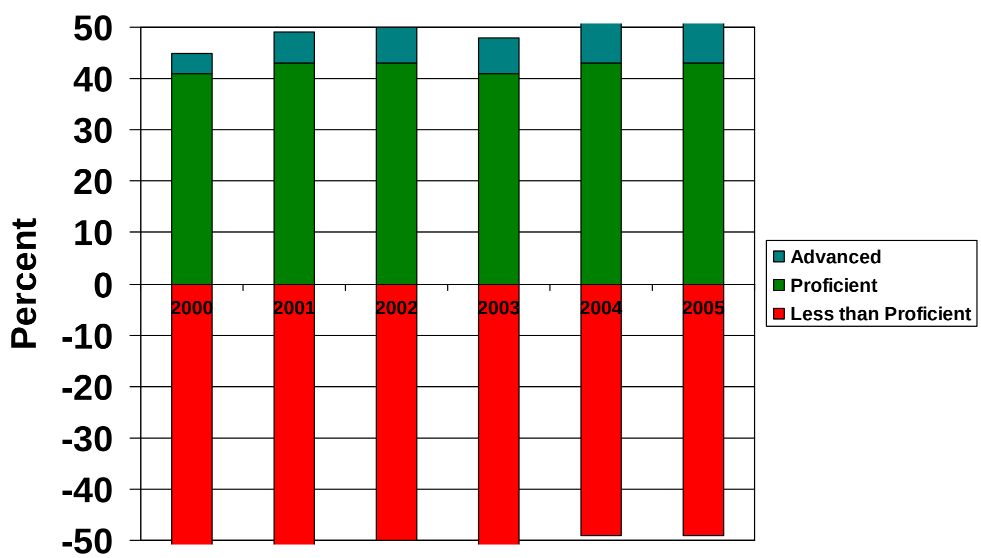
Achievement over Time

Regardless of gender, ethnicity or poverty, students in Colorado are operating below state expectations. Over time, approximately 48% of students statewide scored proficient or advanced on the 8th grade CSAP science assessment.

While the number of students obtaining advanced scores over the last six years has doubled, those who scored proficient and advanced have only gained 6% over six years. The eleventh grade assessment is the Colorado ACT and while a minimum score of 24 (out of a possible 36) in science indicates a likelihood of obtaining a B or higher in a college course in science, only 23% of Colorado students achieve this minimum score.

Regardless of gender, ethnicity or poverty, students in Colorado are operating below state expectations.

Science CSAP Grade 8



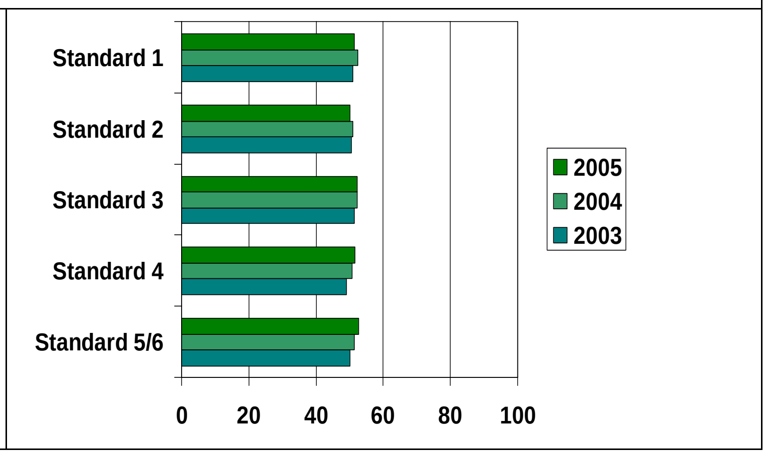
Similarly, the National Assessment of Educational Progress (NAEP), a common, state-to-state assessment, indicates that while only 12 states performed better than Colorado on the 8th grade science assessment in 1996, these rankings represent a 66% failure rate.

With Which Science Standards Do Students Struggle Most?

Each strand of science content knowledge is equally difficult for Colorado's students. Students across regions, demographic categories, gender, and age have a proficiency rate of about 30-40% in Inquiry, Life Science, Earth Science, Physical Science, and the combined Standards of Interrelationships of Science, Technology, and Human Activity and Connections among the Disciplines. In fact, students are not predominantly fluent in any one science arena.

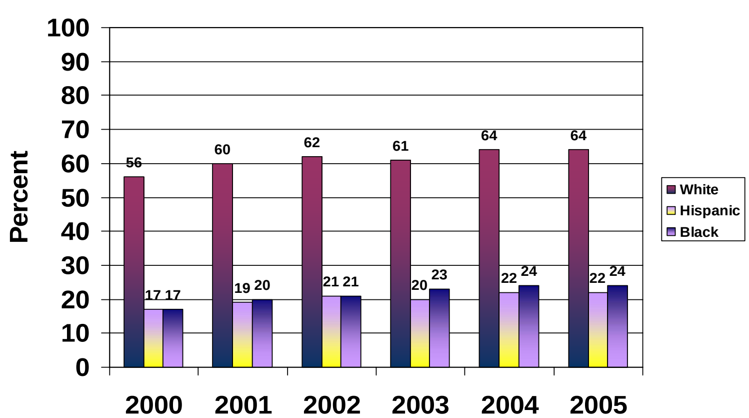
Underneath the Combined Scores: Student Performance by Standards

Science Grade 8



Which Students Struggle Most?

The much-discussed gap in performance between boys and girls is not evident in Colorado. However, a significant gap is apparent between ethnicities with White and Asian students performing three times better than Black and Hispanic students. A similar socio-economic gap is found with approximately 40% fewer students of poverty scoring proficient and advanced on the science CSAP.



The Science Teaching Field

In 2005, there were 3,169 secondary science teachers in Colorado public schools and only 582 of the 23,777 elementary school teachers hold a degree in science. While approximately 75% of Colorado's teachers are trained outside of Colorado, last year Colorado higher education preparation programs produced 385 formally trained science educators, with 151 in undergraduate studies, 78 in post-baccalaureate, and 156 in a graduate program (CCHE).

The state of Colorado has hundreds of science-related affiliations and a handful of science teacher practitioner networks. The most often made remark is about the fractured and almost too copious membership associations available. Unlike other states, Colorado educators prize local control, which leaves science teachers an indeterminate place for advice outside the district.

Colorado candidates for initial educator licenses are required to take and pass a content test for endorsement in any content area(s) in which they will teach. The assessment is intended to determine the content knowledge of those candidates seeking licensing and endorsement and is based on what Colorado PK-12 practitioners and content and preparation program faculty have determined a first-year teacher should know and be able to demonstrate.

Two assessments, as adopted by the Colorado State Board of Education (SBE), were deemed by Colorado's educators to be rigorous and validated:

- The National Evaluation Systems (NES) PLACE test (Program for Licensing Assessments for Colorado Educators) is built on Colorado's teacher performance-based standards, which were, in turn, built on the SBE's-adopted Colorado Student Content Standards.
- The Education Testing Service (ETS) provides an optional nationally based testing instrument, the Praxis II, also adopted by the SBE, in five content areas, one of which is an assessment of content-knowledge in Science, for candidates seeking that licensing endorsement.

Colorado candidates in teacher preparation programs are required to pass their applicable licensing endorsement content exams *prior* to student teaching. This ensures that all Colorado students have teachers that demonstrate competency in science content, *even* when those teachers are in *pre-licensed student teaching* placements.

By August, 2006, and *now*, for those teaching in Title I programs or schools - educators in Colorado must be fully licensed and endorsed, or "Highly Qualified" (indicating that they have completed 24-semester hours in their content area[s] or have passed their content test[s]) in the subject matter they teach.

The Teacher Endorsement Preparation Standards in Science

Colorado science teacher preparation includes and incorporates both nationally recognized science standards and the content knowledge required of Colorado students in the classroom, as identified in Colorado's Student Content Standards.

Colorado's teacher endorsement preparation standards in science were adopted, by the State Board of Education, in September 2003. The Colorado teacher preparation standards are attached in the Appendix.

The content of Colorado science teacher preparation programs is based on three elements:

1. Nationally-recognized science standards for teachers;
2. Colorado's student science content standards; and
3. The candidate's ability to demonstrate science application and *effectively* instruct students in science.

Only a relatively small proportion of Colorado teachers have been prepared under the 2003 State Board of Education-adopted rules. Therefore, correlated student achievement data is not yet available.

Colorado science teacher preparation includes both nationally recognized science standards and Colorado student standards

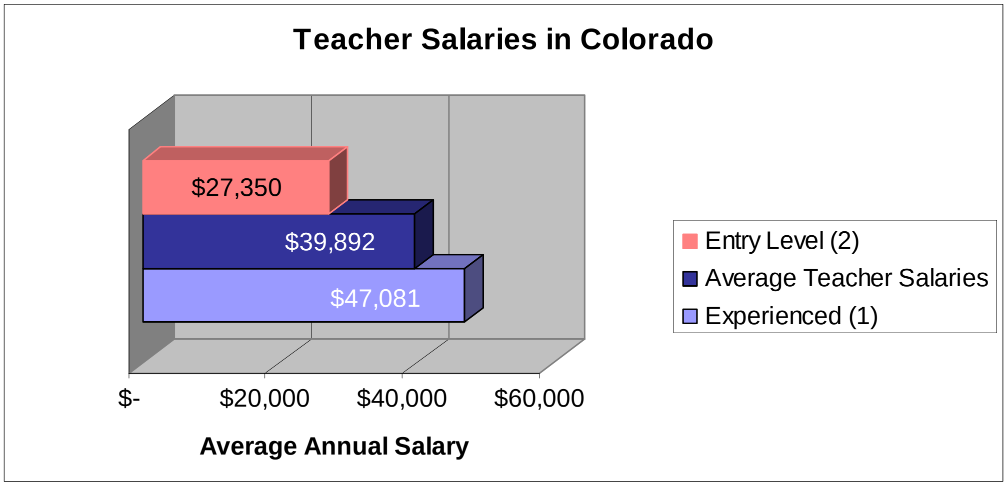
All institutions with *new science programs* are required to show how their programs provide their science teaching candidates with the content knowledge required under the 2003 State Board of Education adopted rules. Higher education institutions with *new science programs* must illustrate how they determine that their candidates can effectively deliver that content.

All institutions with *previously approved* science programs are reviewed on a five-year cycle to insure that the content of their science teacher preparation programs matches the content endorsement preparation standards. If their content does not match, the programs are not submitted to the Colorado State Board for re-approval.

The impact of teacher knowledge on student learning is significant. Teachers who do not have undergraduate training in scientific content have trouble teaching it. In 2005, only 3.5% of the 10,869 students enrolled in teacher education programs in Colorado were enrolled in secondary science licensure programs. Of these, only five were physics majors and fourteen were chemistry majors during their undergraduate studies (CCHE, 2006). Nationwide, 42% of middle school students are being taught physical science by teachers without a major or certification in that field of study (Whitehurst, 2004).

Science Teacher Salaries and the Marketplace

Based on 2003 data (IES, USDOE), the following chart illustrates average Colorado science teacher salaries.



Footnote to Teacher Salaries Graph

1) Experienced Teachers are those with 15 or more years of experience plus a Masters degree.
2) Entry Level Teachers have little experience and no Masters degree.

Colorado teacher salaries have generally been higher in the Metro area and in suburban schools, than those in the Northeast and Southeast regions of Colorado, and in smaller towns that are more rural. Science majors in other fields with comparable levels of education have starting salaries that range on average from $23,000 to $74,000 (US Dept. of Labor, 2004)

Nearly three-quarters of Colorado teachers have been trained in out-of-state preparation programs.

Nearly three-quarters of Colorado's teachers are trained in out-of-state programs. Out-of-state applicants for Colorado educator licenses must provide documented evidence of three-years, or more, of demonstrated teaching experience, or pass their applicable content-area tests. For an initial endorsement, secondary science teachers are required to have 30-hours in science coursework and pass the State Board-approved science content test, and 24-semester hours and passage of the test for an added endorsement (equivalent to the major).

The state educator recruitment web page, www.TeachinColorado.org registered 106 science jobs offered this year, through May 2006. All regions of the state were currently hiring for science positions. Around 7,137 teachers were actively seeking employment at the time of this writing, with 1,121 actively seeking employment related to science instruction.

What Do We Hear and Observe about Science from the Field

As the long term Colorado student performance data was presented in 15 regional presentations throughout the state and during subsequent interviews and classroom observations, the following questions were posed to the field:

- **"What science is being taught in your districts?"**
- **"How are the state science standards working?"**
- **"How are students performing to standards?"**
- **"What do you speculate is the cause of these results?"**
- **"What are some solutions?"**

Messages most repeated across the state:

- Less than proficient science performance was noted across the districts
- A lament existed over the lack of emphasis on science instruction in elementary and middle school
- Positive attitudes that the new 5th and 10th grade science CSAP tests will generate greater attention to science at the elementary and high school levels
- A universal admission that teachers, and particularly elementary school teachers, are not comfortable with the fields of science. Elementary school teachers were said to lack the content experience and secondary science teachers were said to lack experience unpacking the content for delivery.
- Widespread frustration that of all subject areas, science assessment frameworks for grades 5, 8 and 10 are too numerous
- General observation that standards 1, 5 and 6 contain overlapping content
- Many remarks that the CSAP assessment put too much emphasis on facts rather than process
- Concern that the reading demands on the state science assessment distract some students from showing what they do know about science, itself
- Serious concern in small or rural schools about science teacher shortage and the subsequent affect this pinch has on too many science preps for teachers who do instruct science. "The current job market rewards individuals trained in science toward better hours and salaries and away from teaching."
- Concern that some content is more represented and other content is not
- Observations that the science frameworks are more instruction and curriculum-focused than standards and assessment
- At every visit, there was a call for a *voluntary* "scope and sequence" that outlines at each grade level how a science curriculum might successfully unfold

RESEARCH ON SCIENCE COGNITION AND LEARNING

"There is more than a little irony in the disconnect between education science and science education." *Whitehurst, 2004*

There is limited scientific research about science education and very little basic research on learning cognition (Whitehurst, 2004). In the absence of a body of convergent research, educational decisions must be based on research findings from other educational disciplines. Existing theories in science education still need to be tested and science educators need to be prepared to use emerging scientific evidence to guide their teaching practices.

Existing Research on Science Education

Student Misconceptions

"People understand the workings of the world around them in far less detail than they think." Keil, 2003

- Students come to the classroom with misconceptions about scientific concepts (Carey, 2000; Bransford & Donovan, 2005)
- Students' misconceptions impact their observations and findings (Carey, 2000; Bransford & Donovan, 2005)
- Student misconceptions are difficult to change (Carey, 2000; Bransford & Donovan, 2005)
- Teachers need to know science deeply and be familiar with, identify and address the range of misconceptions that may be held by students (Keeley, 2005; Carey, 2000; Minstrell & Kraus, 2005; Bransford & Donovan, 2005)
- Science instruction that explicitly addresses students' everyday ideas helps students to refine or replace them with ones that are more scientifically accurate (Bransford & Donovan, 2005).

Teacher Guided Inquiry

"By exploring concepts, students are better able to think about their understanding so that they can analyze and interpret data, synthesize their ideas, build models, and clarify their conceptual understanding." – Tuomi & Tweed, 2005

- Guided inquiry helps students to develop an understanding of scientific concepts (Bransford & Donovan, 2005; Tuomi & Tweed, 2005)
- Teacher modeling improves students' conceptual understanding (Legleiter, 2005)
- Teacher-centered methods using direct instruction are highly effective for teaching scientific procedures (Klahr & Nigam, 2004)
- Students with knowledge of scientific procedures are able to apply this knowledge to scientific evaluation (Klahr & Nigam, 2004)
- Practice with generating and testing hypotheses raises the average student's achievement (Marzano, Pickering & Pollock, 2001)
- Students **do not** effectively construct knowledge on their own through discovery (Klahr & Nigam, 2004, Chen & Klahr, 1999)

RESEARCH ON SCIENCE COGNITION AND LEARNING

Foundational Conceptual Understandings: *(Magnusson & Palinscar, 2005; Harlen, 2004; NRC, 2000)*

"Scientific thinking involves a complex set of cognitive and metacognitive skills, and the development and consolidation of such skills require a considerable amount of exercise and practice." – Zimmerman, 2005

- Learning to engage in scientific inquiry, engaging in testable questions using evidence to formulate and communicate explanations (Tuomi & Tweed, 2005)
- Scientific standards are different from everyday standards for communicating about how the world works (Magnusson & Palinscar, 2005)
- Patterns in observations are stated as claims (Magnusson & Palinscar, 2005)
- Hypotheses take on the status of claims only after they have been tested (Magnusson & Palinscar, 2005)
- Claims are judged on the quality of the evidence supporting or disconfirming them (Magnusson & Palinscar, 2005)
- Claims are subject to challenge and not considered new scientific knowledge until peer reviewed and accepted (Magnusson & Palinscar, 2005)
- Existing scientific knowledge provides the best explanations available with the understanding that this knowledge may change if new and conflicting evidence is found (NRC, 2000)

Research on Science Standards (Whitehurst)

"*While content standards have become integral to US curriculum development and reform, they have yet to reflect the coherence that is typical of countries that achieve significantly better than the US in the TIMSS study." (Schmidt, Wang, McKnight, 2005)*

There is currently little agreement on which science topics and what sequence of instruction should be taught (Bransford & Donovan, 2005). A comparative analysis of the science taught in the US and the top performing nations on TIMSS 1995 found very different approaches (Schmidt, Wang, McKnight, 2005). The high performing nations do not introduce science topics until 3rd grade, beginning with a few topics and adding to the number of topics hierarchically. In contrast, the US introduces every topic in every grade beginning in kindergarten with no apparent hierarchical sequence.

RESEARCH ON SCIENCE COGNITION AND LEARNING

Applying Cognitive Research in Mathematics to Science

The cognitive research in mathematics finds four essential domains required for mathematical proficiency: procedural knowledge, conceptual understanding, reasoning and applied problem solving. (NRC, 2005)

Potential Model for Building Scientific Proficiency

Scientific Concepts: Comprehending scientific concepts, the broad ideas that can be understood by linking several ideas, specific to and across scientific disciplines. (Bybee, 1997)

Scientific Procedures: Carrying out scientific procedures, such as observation, experimentation, evaluation and generalization, accurately, efficiently, and appropriately.

Scientific Reasoning: Using logic to explain scientific findings and observations of the natural world in order to extend knowledge from something known to something not yet known.

Scientific Inquiry: Investigating scientific questions, generating hypotheses worth investigating and using appropriate concepts and procedures to formulate and communicate reasonable explanations.

Adapted from Helping Children Learn Mathematics

Research in science cognition and learning is currently being conducted via the U.S. Department of Education and the National Institute of Child Health & Human Development. In addition, The National Academies' Board on Science Education is conducting a review of research on how children learn science in Kindergarten through eighth grade. Detailed information about these research projects is available in Appendix B.

COLORADO FINANCIAL RESOURCES FOR SCIENCE INSTRUCTION

Science existing resources

While school and district budget decisions vary, Colorado schools receive from the state up to $165 per student, per year, to purchase equipment, resources, textbooks and supplementary materials for curriculum subject areas. This is over $126 million dollars annually. Most districts use a seven-year cycle of decision-making per subject area. Using a rough average, $80,000 per school is issued per year for these learning resources. Many larger districts obtain overrides to supplement this item of revenue at the local level.

Additionally, other districts administer annual gifts, grants and donations to the science instruction agenda. Some of the above resources are also used, instead, to limit class size or alter the number of instructional classes per day. Every district in the state determines how they will spend their dollars to acquire science textbooks, supplementary material, and science appropriate software during their decision-making year. The state does not approve or deny the local district decisions about how to spend this revenue.

State science initiatives are available to every district. Funding is both state and federally authorized and it can be competitively obtained. Local funding and partnerships include opportunities with such entities as utilities, hospitals and wildlife management agencies. State and national opportunities for science education monies and partnerships are available from such organizations as Toyota Corporation, Lockheed, Boeing and NASA. The funds below are examples of local revenue, state grants and federal initiatives.

A Sampling of 2005-2006 State and Federal Science Dollars

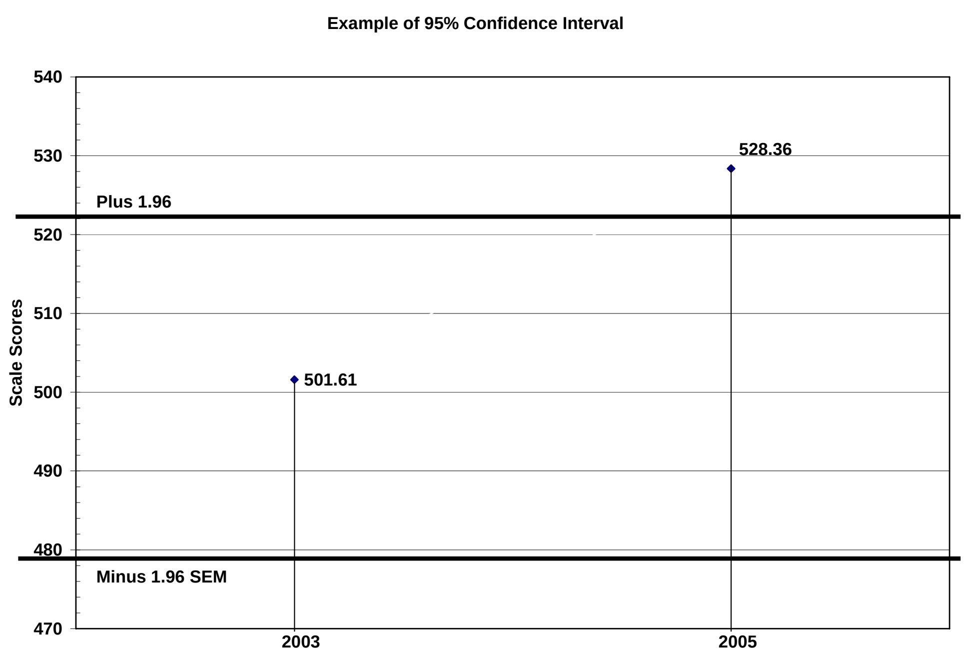
$41,000,000	Average annual Title I and II school and district consolidated math and science resources
$4,000,000	National Science Foundation awards
$584,846	Trio Upward Bound Math and Science competition
$100,000	More than a fifth of McREL services to Colorado annually for professional development and research in science

Middle Schools

Science results on the Colorado Student Assessment Program (CSAP) are currently only available for 8th grade. Beginning Spring of 2006, additional CSAP science assessments will be administered in 5th and 10th grades.

In order to identify schools that have made significant growth on the CSAP 8th grade science test between 2003 and 2005, differences between the average scale scores for 2003 and 2005 were examined. If the 2005 average was higher than the 2003 average for a school, the scores had improved. To find out if the improvement was truly meaningful or statistically significant, a 95% confidence interval was calculated around the 2003 average scale score for each school. The 95% confidence interval took into consideration the average scale scores and standard deviations from 2003 and 2005 as well as the number of students taking the test at each school both years. The 95% confidence interval was used to create a 'target' score for 2005. If a school's 2005 average score exceeded the target score, the school was identified as a 'school that was getting results' in science.

For example, a school had 45 students in 2003 with an average score of 501.61. In 2005, 50 students took the science test and the school had an average score of 528.36. The 95% confidence interval created a target score of 523.44. The actual score of 528.36 was greater than the target score, and this school was identified as a school getting results in science.



What "Science Successful Schools" do to Achieve these Results?

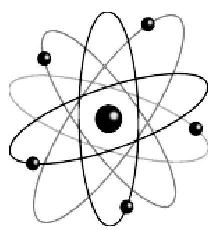
- Recruit and retain **teachers with expertise** and confidence in science who continually seek professional development opportunities.
- Engage their **community and parents** in science activities. Benefit from science-minded and/or **supportive administrators.**
- Know and use the **state standards and assessment frameworks** to align curriculum and pacing of instruction.
- Use both teacher-**directed and guided inquiry** methods of instruction in earth, life and physical science topics.
- **Actively integrate the science topics** into other aspects of the curriculum.

TEN ESSENTIAL SCIENCE IMPROVEMENT RECOMMENDATIONS

1. Identify what pre-conceptions and misperceptions students bring with them into the classroom about the nature of the scientific world around them.

(What are the assumptions we make as teachers about what students already "know" about how the seasons occur or about why lightning strikes?)

An important instructional value in successful science instruction is the ability to determine the misconceptions and assumptions that students carry with them into the classroom lesson. These assumptions are very difficult to determine. They are even more difficult to "undo".



Resource:
A Private Universe: This award-winning program traces the problem through interviews with Harvard graduates and their professors, as well as with a bright ninth-grader who has some confused ideas about the orbits of the planets. Equally useful for education methods classes, teacher workshops, and presentations to the public, ***A Private Universe*** is an essential resource for science and methodology teachers. A free video link is available online at http://www.learner.org/resources/series28.html?pop=yes&vodid=39449&pid=9#

Guiding Questions

1. How do you phrase questions in ways that have students demonstrate
2. the origins of their model of the world or of the elements?
2. What are the multiple ways that elementary middle and high school science lessons can be delivered that force students to identify basic assumptions?
3. Do you provide opportunities for students to express verbally and visually their accepted wisdom about the nature of the world around them?
4. Do you bring notions to the learning discussion that are accurate, for certain?
5. How are these misconceptions of the natural world corrected for you as an adult and incorporated into coherent expectations for which students take responsibility, as well?

TEN ESSENTIAL SCIENCE IMPROVEMENT RECOMMENDATIONS

2. Be clear about the science topics that Colorado students are expected to know at each grade level.

(Your students' science performance is assessed on these science standards and assessment frameworks.)

The Assessment Frameworks are the elements of the state standards that are the exclusive science topics, which make up the state test questions. One of the most apparent differences between classrooms, which have stronger student science performance, and those classrooms that have low student science performance is teacher and student knowledge of these science elements.

Resources:

A) The Colorado Model Content Standards and CSAP Assessment Frameworks for Science: http://www.cde.state.co.us/cdeassess/csap_frameworks.html

Colorado's StandardS

B) American Association for the Advancement of Science - Benchmarks http://www.project2061.org/publications/bsl/online/bolintro.htm

C) National Science Education Standards http://www.nap.edu/readingroom/books/nses/6b.html

Guiding Questions

1. How many of your teachers use these science frameworks in their daily instruction?
2. To what degree do your textbooks or activities address these topics and vocabulary words at the proficient level?
3. Are your students introduced to these at the beginning of school or at the first of each lesson?
4. How many of your parents know these as the primary objectives and science vocabulary for their children, for home conversations?
5. How much of your job performance review is based on these science expectations?
6. Are you recruiting, hiring and retaining science teachers who use these science expectations and are effective at moving students to these science topics at proficient levels?

TEN ESSENTIAL SCIENCE IMPROVEMENT RECOMMENDATIONS

3. Build a focused and intentional district curriculum of concepts, knowledge and skills to avoid a shallow and excessively broad span of topics each year.

(Ask a student a question about why forces operate as they do and are you finding that students do not have a foundational understanding of the principles of the natural world adequately understood to make meaning of your question?)

Students in other countries study science in greater depth. The United States science curricula are often numerous in topics and thin about the meaningfulness of principles.

Resource:
McREL – Designing Effective Science Lessons
a four-part professional development program aimed at increasing the quality of science lessons with strategies that teachers can use immediately and on their own. For more information: http://www.mcrel.org/topics/serviceDetail.asp?serviceID=97

Guiding Questions

1. How do you discuss the scope and sequence of science instruction with your science colleagues at all grades?
2. How are your students taught to understand the relationships of concepts and facts in a coherent way?
3. Does your science instruction invite depth?
4. Do you explicitly teach science in ways that encourage students and parents to question and discuss their personal understanding of scientific inquiry, physical, life and earth and space content?
5. Do your teachers have the depth of knowledge necessary to provide accurate explanations that are comprehensible and useful for students?
6. How do you invite students to discuss and explore science concepts?

TEN ESSENTIAL SCIENCE IMPROVEMENT RECOMMENDATIONS

4. Guarantee that all students, each year, are deeply engaged in rigorous and developmentally appropriate life, physical and earth/space science instruction.

(Current science practice is often not rigorous or deep. Why?)

Robust national and state science instruction is tempered by both tepid elementary school teacher's beliefs and minimum comfort in the field of science and a concurrent belief in many communities that science is not for all students.

Resource:
Please visit the Colorado Science website for profiles and resources from schools that get results in science.

http://www.cde.state.co.us/coloradoscience.htm

Guiding Questions

1. Are your teachers discussing how to structure coherent science curriculum?
2. How does your district discuss with teachers the approaches necessary to deliver deeper science topics?
3. Who is identifying richer and more interesting science materials into both the school and community?
4. What messages do your science lessons over time send to your students about the value of science in daily life and in career possibilities?

TEN ESSENTIAL SCIENCE IMPROVEMENT RECOMMENDATIONS

5. Be clear about what specific proficient student work looks like in science at each grade level.

(Do you know what "good enough" student work looks like for each science topic?)

The degree to which students can demonstrate what they know is very often underestimated. Do you know what work that is typical of a partially proficient scoring student looks like at each grade level? Half of the reported grades given in Colorado classrooms are far more generous than what the state assessment considers grade level work.

Resources:

C) Examples of high performing and low performing, middle school student work:
http://www.cde.state.co.us/cdeassess/released_items.html
Grade 8 available ; Development of an in-depth science guide is in progress.

D) Performance Level Descriptors:
http://www.cde.state.co.us/cdeassess/csap_plds.html#Science
Grade 8 is available. Grades 5 and 10 will be available in Summer 2006.

If your daily class questions, homework and quizzes are not graded at these kinds of performance thresholds, you and your students are not on par with the state expectations. If you don't know or don't believe your students can or should do this level of science performance, consider the impact of beliefs and dispositions (see recommendation #3).

Guiding Questions

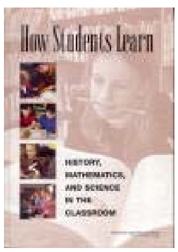
1. How many of your teachers use these science frameworks as the grade level performance thresholds for daily progress monitoring and student grades?
2. How many of your students know these performance expectations?
3. How many of your parents know these performance expectations?
4. Are students entering each new grade level with the prerequisites to perform at grade level?

TEN ESSENTIAL SCIENCE IMPROVEMENT RECOMMENDATIONS

6. Insist on a balance of explicit teacher-directed science instruction and teacher-guided student inquiry into science.

(Who is in control of the final message students have when they leave your science classroom? How do you grow over time an independent scientific thinker? How do you build a gradual accumulation of <u>accurate</u> assumptions? How do these build a body of work that gives students power to reflect on bigger ideas?)

Science is about discovering and uncovering the natural world around us. Science instruction research, however, demonstrates the importance of having students end their exploring with a certainty about the conclusions teachers intend students to have at the end.



Resources:
How Students Learn: History, Mathematics, and Science in the Classroom, National Research Council, 2005

The science of learning science. Whitehurst, G. Secretary's Summit on Science. Washington, DC: U.S. Department of Education Institute of Education Sciences.

Guiding Questions

1. How do your questions prompt students to explain and justify logical solutions to problems?
2. How do you address faulty reasoning by students?
3. Do your teachers have the depth of knowledge necessary to respond productively to students' scientific questions and curiosities?
4. What opportunities do students have to provide logical verbal and written explanations of their reasoning? How do they augment their thoughts and express new hypotheses?
5. How do the final results make sense without the teacher being the sole director and producer of activities?

TEN ESSENTIAL SCIENCE IMPROVEMENT RECOMMENDATIONS

7. Diagnose what your students understand about the lesson of the day with lab based activities, writing tasks and proofs.

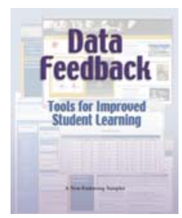
(Do you ask students each day to explain what they think they know after the lesson? Do you summarize the main point of the lesson and ask students to do the same?)

The chief characteristic of a great science teacher includes asking students the best questions:

- *"How might my students have gotten confused about this topic?"*
- *"What assumptions are they making?"*
- *"How can I explore the misperceptions of my students and engage them in doing similar self-questioning for better understanding?"*

Resources:

Sample feedback tool for sciences: Please see *Data Feedback*, a publication by the Colorado Department of Education, available through Interlibrary Loan at: http://cde.carl.org/cgi-bin/cw_cgi?fullRecord+28556+28+2032320393+1+0



Guiding Questions

1. What other than your textbook end of chapter questions, do you use to monitor science progress?
2. Does you school facilitate time for teachers to offer labs? When do they discuss student work and science performance data?
3. Does your district invest in the professional development necessary to grow teachers' capacities to diagnose students' science abilities?
4. How do you grow your teachers' depth of knowledge to interpret and make scientific judgments about students' questions, solutions, problems, and insights in science?

8. Check school and teacher beliefs and dispositions about how many students can or should know science.

(Your belief in your students' capacity to understand the science affects enormously the chances of students' science success.)

Teaching a science lesson in order to cover the topic was once the job description. Teaching a science lesson with the requirement all students become engaged and proficient in the concepts makes for an entirely different science lesson. Teachers with a productive disposition help students to see science as sensible, useful and doable.

Resource:

A selection of Middle Schools that are exceeding student performance expectations over three years
http://www.cde.state.co.us/coloradoscience.htm

Guiding Questions

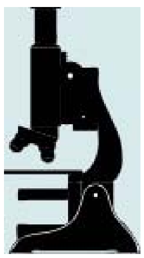
1. How many of your students believe their teacher is inclined to be excited about science and believe that all of their students can become proficient?
2. Do you have a science department that talks about the science lessons, which engage all student knowledge?
3. To what degree do your teachers have the drive to know which students are confused and follow through on the ways to get them unstuck?
4. To what degree do your teachers know how to extend science lessons beyond what is presented in the curriculum?
5. How do you foster the excitement for teacher (adult) growth and enthusiasm for science?

TEN ESSENTIAL SCIENCE IMPROVEMENT RECOMMENDATIONS

9. Recruit and develop teachers with knowledge of science concepts, learning and instruction.

(Your teachers' knowledge of science and science instructional practices significantly impacts your students' science achievement.)

Many elementary and middle school teachers do not feel they have sufficient understanding of the science they teach. While knowledge of science is a critical factor in teaching science, it is not sufficient to guarantee effective instruction.



Resources:
Science Mathematics Educator Standards (Appendix A)
http://www.cde.state.co.us/cdeboard/download/bdregs_301-37.pdf

Colorado Recruitment web page: www.teachincolorado.com

Guiding Questions

1. What level of science background and training do your teachers have?
2. How are you providing professional development for teachers who need more content knowledge?
3. How are you recruiting teachers with strong science backgrounds to your school?

TEN ESSENTIAL SCIENCE IMPROVEMENT RECOMMENDATIONS

10. Ensure that other subject areas are reinforced and used in science instruction.

(Are you asking students to demonstrate math and reading skills in the science lessons you offer?)

Mathematics is the language of science. Science research is dependent on reading skills. Proficient writing skills are necessary to convey scientific findings. Science is a critical culminating focus for all the core subjects.

Resources:
Curriculum mapping. This common sense idea championed by Dr. Heidi Hayes Jacobs -- the recognized pioneer of curriculum mapping -- over ten years ago is now supported both by research and thousands of personal stories that relate how mapping improves student performance.
http://www.clihome.com/cm/

Guiding Questions

1. Most students are not asked to incorporate deeper mathematics in their science work. How can your instruction demand mathematics thinking, as well?
2. How much does coherent expression and concise descriptive writing factor into your science classroom weighted grade?
3. Do your teachers have the depth of knowledge necessary to pose mathematical questions and problems that are productive for students' learning?
4. Most teacher questions are posed with less than a three-second delay between question and expected student response. How might you invite prolonged thinking time for students to comprehend the reading assignments and research behind the science lesson?
5. How are other teachers encouraged to integrate your activities with their subject–specific lessons?

SUMMARY OF THE 10 ESSENTIAL SCIENCE IMPROVEMENT RECOMMENDATIONS

1. Identify what pre-conceptions and misperceptions students bring with them into the classroom about the nature of the scientific world around them.	An important instructional value in successful science instruction is the ability to determine the misconceptions and assumptions that students carry with them into the classroom lesson. These assumptions are very difficult to determine. They are even more difficult to "undo".
2. Be clear about the science topics that Colorado students are expected to know at each grade level.	The Assessment Frameworks are the elements of the state standards that are the exclusive science topics, which make up the state test questions. One of the most apparent differences between classrooms, which have stronger student science performance, and those classrooms that have low student science performance is teacher and student knowledge of these science elements.
3. Build a focused and intentional district curriculum of concepts, knowledge and skills to avoid a shallow and excessively broad span of topics each year.	Students in other countries study science in greater depth. The United States science curricula is often numerous in topics and thin about the meaningfulness of principles.
4. Guarantee that all students, each year, are deeply engaged in rigorous and developmentally appropriate life, physical and earth/space science instruction.	Robust national and state science instruction is tempered by both tepid elementary school teacher's beliefs and minimum comfort in the field of science and a concurrent belief in many communities that science is not for all students.
5. Be clear about what specific proficient student work looks like in science at each grade level.	The degree to which students can demonstrate what they know is very often underestimated. Do you know what work that is typical of a partially proficient scoring student looks like at each grade level? Half of the reported grades given in Colorado classrooms are far more generous than what the state assessment considers grade level work.
6. Insist on a balance of explicit teacher-directed science instruction and teacher-guided student inquiry into science	Science is about discovering and uncovering the natural world around us. Science instruction research, however, demonstrates the importance of having students end their exploring with a certainty about the conclusions teachers intend students to have at the end.
7. Diagnose what your students understand about the lesson of the day with lab based activities, writing tasks and proofs	The chief characteristic of a great science teacher includes asking students the best questions.
8. Check school and teacher beliefs and dispositions about how many students can or should know science.	Teaching a science lesson in order to cover the topic was once the job description. Teaching a science lesson with the requirement all students become engaged and proficient in the concepts makes for an entirely different science lesson. Teachers with a productive disposition help students to see science as sensible, useful and doable.
9. Recruit and develop teachers with knowledge of science concepts, learning and instruction.	Many elementary and middle school teachers do not feel they have sufficient understanding of the science they teach. While knowledge of science is a critical factor in teaching science, it is not sufficient to guarantee effective instruction.
10. Ensure that other subject areas are reinforced and used in science instruction.	Mathematics is the language of science. Science research is dependent on reading skills. Proficient writing skills are necessary to convey scientific findings.. Science is a critical culminating focus for all the core subjects.

SIX STATEWIDE SCIENCE SUPPORT SYSTEMS FOR SCHOOLS

Local control of science curriculum in Colorado and the presence of only one state science assessment for six years has isolated too many science educators from resources and policy supports. Six support systems do exist to put a forced focus on the very best science practices for our science educators. This more precise focus has not always been applied, but could make a significant difference, especially to any school or district that does not always have local resource, or time to enhance science instruction beyond usual practice.

Below are possible recommendations of how each professionally supportive network might extend their own reach to effectively disseminate what we know about:

- *The Colorado Science Standards*
- *The **essential** evidence of excellent science instruction*
- *The best resources and professional development*
- *The most promising science grants*
- *The habits of science- successful schools*

1. Science Support System: Education Leadership Associations and District Administrators

a. Raise awareness and celebrate the critical role both administrators and teachers play in improving science performance. Examine in print and visit schools and districts called out as improving science achievement. Note the synergy and success of an intentional leadership agenda in science.

b. Promote teacher supervision and evaluation practices aligned with the essential domains of science instruction **and** the habits of classrooms with consistent science success.

2. Science Support System: Local School Boards and Community Support

a. Promote the explicit value science has in the local economy at large

b. Consider the findings of this science report in science teacher and administrator hiring's.

c. Design community-wide and on-going science events and school to career activities that feature the benefits, salaries and advantages of science in the quality of life nearby

d. Discuss at local school board meetings the interim successes and gaps made with students in science achievement

SIX STATEWIDE SCIENCE SUPPORT SYSTEMS FOR SCHOOLS

3. **Science Support System: Higher Education**
   a. Reinforce the 2003 amended Colorado Teacher Performance Standards, through recognition of teacher preparation programs that have demonstrated effective incorporation of Colorado Standards as the keystone of their programs.
   b. Ensure that teacher preparation programs include the state's science assessment frameworks in their fieldwork and student teaching applications.
   c. Publicize documented success stories, with regard to the correlation between science preparation and candidate success with student achievement.
   d. Like the Colorado School of Mines and University of Northern Colorado, invest in new paradigms and centers that redefine science students from intellectual oddities into relevant and essential business thinkers who will lead our society forward.
   e. Offer middle school and high school students mentors who model and guide students into productive networks, research and job opportunities. Building a cadre of young science minded people foster secondary schools, which offer Advanced Placement and other rich supports.
4. **Science Support System: Teacher Networks and Associations**
   a. Continue their teaching and learning leadership and outreach to teachers of science.
   b. Electronically disseminate the science assessment frameworks and science vocabulary lists, video clips of teaching and learning examples of the direct and inquiry based science instruction and names of their colleagues who are being recognized for science achievement in their region.
   c. Encourage even stronger partnerships with local community colleges and universities in order to build an intentional and long-term science mentor program for new science teachers and emerging science leaders among and between professional teaching groups and science leader groups.
5. **Science Support System: Colorado Department of Education**
   a. Develop a Colorado Science webpage with resources for school districts.
   b. Offer, once a year, CTB/McGraw Hill scoring feedback "webinars" to teachers regarding specific observations about annual student science performance.
   c. Electronically issue annual, specific examples, by grade level, of student performance benchmark reminders and science anchor papers.
   d. Leverage all federal and state dollars issued by CDE around much more precise expectations for science practice.
   e. Post annually the names of schools that move student science performance in significant ways.

SIX STATEWIDE SCIENCE SUPPORT SYSTEMS FOR SCHOOLS

6. Science Support System: Professional Science Associations

a. Subsidize annual science opportunities and conferences from a variety of partners. This enhanced version may include “webinars”, more science software exhibitions, a larger university presence or even more opportunities for teachers to have funded sabbaticals with authentic science experiences.

b. Financially contribute more to very successful science school-level projects, which “seed” intensive and successful science teacher professional development.

c. Tap and promote the research pools of McREL and other networks for research and video images of benchmarked examples of excellent science instruction.

d. Encourage the financial and intellectual support for both new and veteran teachers of science through courses offered by science departments and schools of education that develop strong science educators.

e. Highlight professional development in science content, science assessment and science instruction based on both the findings of science research and student needs assessment to support science teachers seeking certificated renewal in science-related fields.

f. Provide more names of regional science teachers, professional scientists, serious science users and collegiate science teachers who can coach, discuss how to introduce science principles, build provocative science problems and pose interesting science questions.

g. Post the names of teachers who are excellent at diagnosing and discussing specific pedagogy barriers that are appearing in classrooms and with specific learning challenged students.

h. Consider the benefits of a Colorado science newsletter for thousands of Colorado science educators that exclusively identifies Colorado Model Science Content Standards and lessons that effectively teach student to grade level.

CONCLUDING STATEMENTS

While the Colorado economy is arguably one of the most science-dependent in the nation, its own K-12 science education results produce less than 50% of its students competent at grade level in science. According to NAEP results, Colorado ranks within the top 15 in the nation for science achievement results. However, this reflects only a 34 % proficiency rate in eighth grade, respectively.

Science teachers in Colorado are challenged with finding ways to make science instruction a priority at the local district level. The addition of fifth and tenth grade science tests this 2005-06 will put a new energy into local schools to ask for and examine specific science goals and grade-by-grade student science expectations.

After a yearlong course of study about Colorado science instruction, five consistent signals appear to exist. First, elementary school teachers admit to not know science deeply. Explicit and sequenced science instruction is not clearly articulated in these grades. For six years, the state science assessment only existed in the eighth grade. Schools and districts often equated school accountability with local curriculum priorities. For this reason, science has not always been a focus for local elementary professional development and curriculum assembly.

While the Colorado economy is science dependent…its own K-12 education results produce less than 50% of its students competent at grade level in science

The second message is that Colorado science delivery has a heavy emphasis on inquiry and a lighter value to teacher directed instruction. BOTH are necessary to reach students effectively and engage them at the standards. Exploration kits and discovery methods do not have evidence in research that students always deeply learn the science fundamentals.

The third message is the absence of singular science leadership in the state for science educators. While there are arguably hundreds of science-minded groups in Colorado, there is no one clearinghouse for the best science materials, science teacher professional development and networking. This lack of intentional science partnerships means that corporate, university and national resources, while they do appear, are splintered and not necessarily aligned with the state's science standards or the most effective research.

The fourth science education observation is the significant number of misconceptions students and teachers bring to the science classroom about how the natural world works. These assumptions are difficult to determine and even more difficult to correct! For example, how a lunar eclipse is formed or the behavior of birds in migration are answered by students with irrational assumptions.

CONCLUDING STATEMENTS

The final message is the significant influence of communities and families to impart powerful signals to their children about the value of science, even when the school does not have such explicit expectations for their students. In regions where the intellectual science elite have children or where agricultural interests are discussed and used each day and in civic activities, we see student achievement rise. The identity students carry with them about the utility and necessity of science in everyday life or in a future professional life is a major factor in determining student science success.

The significance of this report is a call to examine the forthright dedication this state has to science education. Do state educators and citizens believe that students should have a rigorous and deeply engaging sequence of science instruction? How committed is the state to surrender the hundreds of state science agendas to identify the best science education for its new science teachers and find mechanism to reach its veteran science teachers? A statewide priority dedicated to science achievement will require a sharpened focus to having our youngest students exposed to physical, life and earth science in more intentional ways. How do grants, education awards, teacher education programs, professional development, and evaluation begin to align to the state science standards and to more students reaching those grade appropriate achievement levels.

As a state with science interests and collegiate investments in these fields, we owe it to all of our citizens to re-commit a local and state focus to this effect.

APPENDIX A – COLORADO TEACHER PREPARATION STANDARDS

8.17 **Science Education.** To be endorsed in science education, an applicant shall hold a bachelor's or higher degree from a four-year accepted institution of higher education, have completed an approved teacher preparation program; an approved program in science education; and have demonstrated the competencies specified below:

(1) The science educator is knowledgeable about the content of the sciences, and is able to effectively instruct students regarding:

(a) physics, chemistry, biology, earth and space science, environmental science, and applicable mathematics, and

(b) shall have completed an area or areas of concentration in, demonstrate knowledge of and effectively instruct students about one or more areas selected from:

(i) physics to include, but not be limited to: general and experimental physics, mechanics, electricity, magnetism, quantum and atomic physics, sound, and optics.

(ii) chemistry to include, but not be limited to: general chemistry, organic chemistry, inorganic chemistry, analytical chemistry, and physical chemistry.

(iii) biology to include, but not be limited to: general biology, environmental biology, biotechnology, genetics, evolution, human anatomy, ecology, molecular biology, and matter and energy in living systems.

(iv) earth and space science to include, but not be limited to: historical and physical geology, astronomy, environmental science, meteorology, oceanography, geomorphology, stratigraphy, mineralogy, and earth systems.

(v) general science to include, but not be limited to: general chemistry, physics, biology, earth and space science, environmental science, and applicable mathematics.

(2) The science educator is knowledgeable about and is able to:

(a) effectively articulate to students, current issues and events affecting or affected by science; age-/grade-appropriate controversial topics, from multiple science perspectives, including historical and philosophical bases; and an analytical approach to students, with clarity and without bias.

(b) effectively demonstrate to students, and instruct them about the use of a wide variety of science tools; primary and secondary source materials; print resources; laboratory and natural settings; and technological resources.

(c) effectively instruct students about: the design of experiments; data reporting; use of appropriate and relevant technology; interpretation of results; and the steps which may be taken in the presentation of the processes involved and the results obtained.

APPENDIX A – COLORADO TEACHER PREPARATION STANDARDS

(e) effectively integrate technology into instructional and assessment strategies, as appropriate to science education and the learner.
(f) effectively instruct students about the connections between and among the various
science disciplines and within other disciplines, where relevant and appropriate.
(g) effectively demonstrate for and instruct students about, the basic elements of the nature of science, including, but not limited to: inquiry, curiosity, discovery, openness to new ideas, and skepticism.
(h) effectively communicate to students about the historical and dynamic nature of science.
(i) demonstrate, for students, the connection between an inquiry-based lesson and a larger conceptual-based module, and the linkage of both to state-approved student science content standards.
(j) effectively demonstrate, and instruct to students about, the linkage(s) between curriculum, instruction, and assessment, as related to state-approved student science content standards.
(k) effectively demonstrate, and instruct to students about, safety considerations in science instruction and in the science classroom, including, but not limited to:

(i) proper use, storage, and disposal or maintenance of biological, chemical, and scientific equipment, and specimens, and is able to:
(ii) instruct and supervise students in the proper preparation and use of laboratory equipment and materials.
(iii) evaluate laboratory settings, equipment, materials and procedures, to identify and manage the resolution of potential safety hazards.
(iv) provide solutions to equipment problems, with the ability to make minor adjustments in the operation of equipment.

(l) incorporate, into planning, information related to state and federal regulations, legal issues, and guidelines pertaining to scientific materials and specimens.

(3) Field experiences: have completed supervised field experience in an elementary or secondary
school at the appropriate grade level(s) for endorsement.
(4) The science educator shall self-assess the effectiveness of instruction, as based on the achievement of students, and pursue continuous professional development, through appropriate activities and coursework, and through participation in relevant professional organizations.

APPENDIX B- RESEARCH INITIATIVES

U.S. Department of Education

Mathematics and Science Initiative

http://www.ed.gov/rschstat/research/progs/mathscience/index.html

The Secretary's Mathematics and Science Initiative was launched in February 2003 to:

- Engage the public in recognizing the need for better mathematics and science education for all children.
- Initiate a campaign to recruit, prepare, train, and retain teachers with strong backgrounds in mathematics and science.
- Develop a research base to improve knowledge of what boosts student learning in mathematics and science.

Institute for Educational Sciences (IES)
National Center for Education Research

The mission of the National Center for Education Research is to: 1) sponsor sustained research that will contribute to the solution of education problems and lead to the accumulation of knowledge about education to ensure that all children have access to a high-quality education, improve teaching and learning and student academic achievement, close the achievement gap, and improve access and opportunity for postsecondary education; 2) support research syntheses and promote the use of scientifically valid research findings to improve education policy and practice; 3) Promote quality through the use of accepted practices of scientific inquiry to gain knowledge about the validity of education theories, practices, or conditions; and 4) Promote scientifically valid research findings that can provide the basis for improving academic instruction and lifelong learning.

Cognition and Student Learning Research Program

http://www.ed.gov/programs/cognition/index.html

The purpose of the Cognition research program is to improve student learning by bringing recent advances in cognitive science to bear on significant problems in education. The long-term outcome of this program is to develop approaches to instruction that are based on principles of learning and information processing gained from cognitive science and to provide evidence of their usefulness in education settings.

Mathematics and Science Education Research Program

http://www.ed.gov/programs/mathresearch/index.html

The Institute intends for the research program on Mathematics and Science Education (Math/Science) to fulfill five goals: (1) identifying curriculum and instructional practices that are potentially effective for improving mathematics or science outcomes, as well as mediators and moderators of the effects of these practices; (2) developing new interventions and approaches to mathematics and science education that will eventually result in improving mathematics and science achievement; (3) establishing the efficacy of existing interventions and approaches to mathematics and science education with small efficacy or replication trials; (4) providing evidence on the effectiveness of mathematics and science interventions implemented at scale; and (5) developing and validating assessments for diagnosing sources of mathematics difficulties. The long-term outcome of this program will be an array of tools and strategies (e.g., curricula, programs) that have been demonstrated to be effective for improving mathematics and science learning and achievement.

APPENDIX B –RESEARCH INITIATIVES

National Institutes of Health

National Institute of Child Health & Human Development

Mathematics and Science Cognition and Learning – Development and Disorders

http://www.nichd.nih.gov/about/crmc/cdb/math.htm

This Program encourages both basic and intervention research in all aspects of mathematical thinking and problem solving, as well as in scientific reasoning, learning, and discovery. An important priority within this Program is the investigation of individual differences that may moderate achievement in math and science. Of particular interest is the delineation of skill sets needed to attain proficiency in these domains, the means to address the kinds of learning difficulties that frequently emerge in each of these areas, and the development of effective instructional methods for mitigating these difficulties.

Science Cognition and Learning

This area of programmatic emphasis seeks studies that will improve understanding of the cognitive and developmental bases of scientific thinking and learning. Research on factors contributing to conceptual change is especially encouraged, as are studies of inductive and deductive reasoning, and the acquisition of scientific concepts such as experimental control and falsifiability. Related topics of interest include causal thinking and inference, theory-evidence coordination, and reasoning about data. Another area of importance is the investigation of developmental changes in naïve or intuitive thinking about the biological and physical worlds. The Program also supports studies that can inform the design of evidence-based, instructional interventions.

The National Academies

National Research Council
Center for Education

http://www7.nationalacademies.org/cfe/

The Center's mission is to promote evidence-based policy analysis that is both responsive and anticipatory: responsive to government's and other stakeholders' program and research interests; and anticipatory of long-term challenges, opportunities, and needs that affect the future of education research and policy priorities.

Division of Behavioral and Social Sciences and Education

http://www7.nationalacademies.org/bose/

The Board on Science Education (BOSE) is a standing board within the Division of Behavioral and Social Sciences and Education and the Center for Education at the National Research Council, the operating arm of the National Academies. The leadership for the Board consists of a chair and an executive committee who will work with the director of the Board and the Board staff. The Board meets biannually and its membership reflects expertise in a variety of domains within science and science education such as scientists, learning and developmental theorists, cognitive scientists, educational researchers, science teachers and faculty across all education levels, policy specialists, informal education leaders, teacher educators and corporate stakeholders. Board members have been nominated and approved through processes established by the National Academies.

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National Center on Education Statistics (NCES) -www.nces.ed.gov

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RESOURCES

A. The Colorado Model Content Standards and CSAP Assessment Frameworks for Science.
http://www.cde.state.co.us/cdeassess/csap_frameworks.html

B. Examples of High & Low Quality Middle School Student Work.
http://www.cde.state.co.us/cdeassess/released_items.html

C. Anchor Papers.
http://www.cde.state.co.us/cdeassess/released_items.html

D. A Selection of Middle Schools Exceeding Student Performance Over Three Years.
http://cde.state.co.us/coloradoscience/recognition.htm

E. Research Initiatives in Science.
http://cde.state.co.us/coloradoscience/research.htm

F. "Data Feedback: Tools for Improved Student Learning." Office of Learning and Results, Colorado Department of Education, 2004. Sample "Benchmark" provided by Edison.
http://cde.carl.org/cgi-bin/cw_cgi?fullRecord+28556+28+2032320393+1+0

OFFICE OF LEARNING AND RESULTS

Colorado Department of Education
Office of Learning and Results
201 East Colfax Avenue
Denver, CO 80203