# Education Transition Assessment Team Report – Mathematics & Science Instruction

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## ABSTRACT

This report identifies the mission of mathematics and science instruction as preparation of all students for continued STEM (science, technology, engineering and mathematics) learning opportunities, career choices and informed participation in civic life. Recent trends relevant to STEM education are identified. Effectiveness of our state in fulfilling the mission of mathematics and science instruction is assessed as being less than what the very best education systems are capable of achieving. Causation for our current state of effectiveness is explored through the lenses of the SCCMS/S$^2$MART Centers Theory of Action for Instructional Improvement. Additionally, this report speculates on what might become of mathematics and science instruction in the years ahead.

## AUTHOR'S NOTES

This does not purport to be a technical report. Rather, it represents what is hoped to be the beginning of an ongoing dialog focused on improving instruction and accelerating student learning in mathematics and science. As such, the author has purposefully chosen a conversational tone mixing knowledge about our state's schools acquired from years on the "front lines" with supporting data and reference to robust technical reports developed by national experts.

The views expressed within this report, for which neither data nor reference to technical reports are provided, are those of this author alone. These views have been informed by ideas and information shared in dialog with or submitted for consideration by South Carolinians from all walks of life and representatives of our state's various professional organizations having interest in mathematics and science instruction.

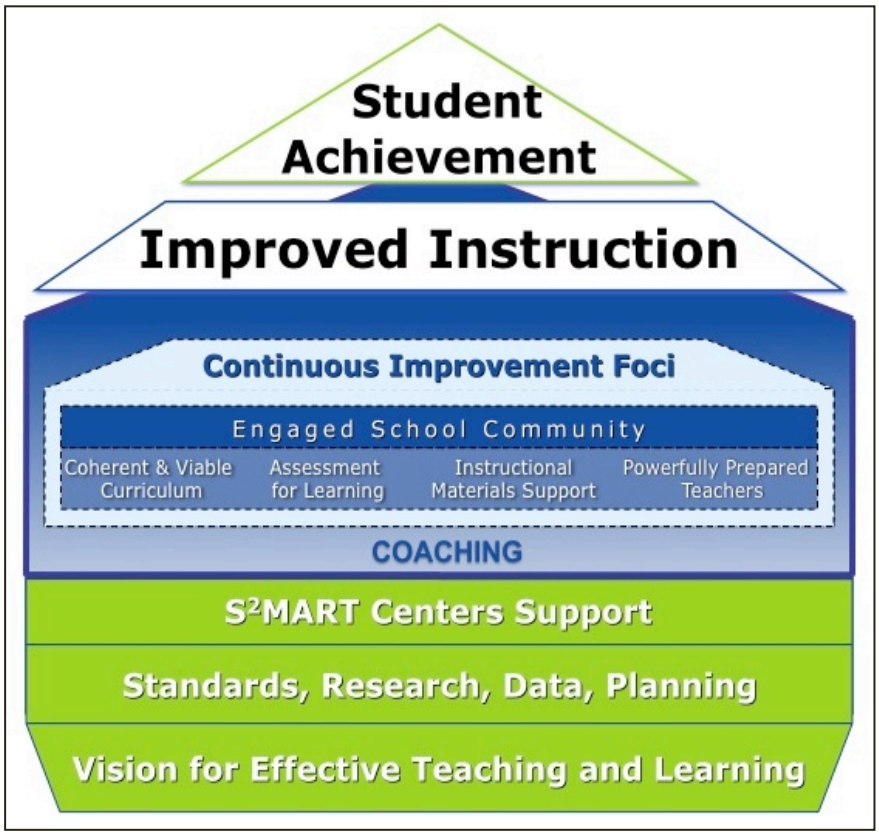
This report is organized around the SCCMS/S$^2$MART Centers Theory of Action for Instructional Improvement. SCCMS is most grateful to the National Science Resources Center (NSRC) for its articulation of a Theory of Action for Instructional Improvement in K-8 science. South Carolina's association with the NSRC's National Science Foundation funded Leadership and Assistance for Science Education Reform (LASER) initiative from 1998 through 2003 was pivotal in guiding our planning and practice in instructional materials support and instructional coaching. Our modification of this Theory respects the origins and intent of the original.

This Theory of Action is sometimes silent on specific items of interest requested in the guidelines for this report. Where this is the case, I have added the items in areas I feel are appropriate. These items are noted by text that is fully capitalized and blue in color (e.g. PRIMARY MISSION).

## Our Theory of Action

A Theory of Action, quite simply, is a way of expressing an organization's intended pathway to desired outcomes. Our intended outcomes are engaged school communities focused on improved instruction in mathematics and science leading to accelerated student achievement.

*Figure 1. SCCMS/S²MART Centers Theory of Action for Instructional Improvement*




While the pathway to student achievement defined by our Theory of Action is complex as enacted, it is simple in its basics:

- A common vision for improved instruction based on robust learning standards and informed by research on teaching and learning. This vision is tempered by data generated when well-thought plans of action for instructional improvement are implemented in schools.

- A well-supported community of learners engaged in actions known to matter in improving instruction. These include making good curriculum choices, employing meaningful assessment tools, supporting instructional materials and technologies needed as inquiry tools, and preparing teachers to know both their content and effective ways to facilitate learning in their discipline.

## Vision for Effective Teaching & Learning

### PRIMARY MISSION

There are many good reasons for learning mathematics and science. The content and ways of thinking associated with these disciplines are known to be relevant to continued learning opportunities, career choices and informed participation in civic life. Thus, we see the primary mission of K-12 mathematics and science instruction as preparation of all students for these opportunities.

### HISTORICAL CONTEXT

> *We are caught in-between what was and what might be.* (Anonymous contributor)

Trend 1 - Moving to STEM (Science, Mathematics, Engineering & Technology).

In 2001, the landscape of mathematics and science instruction in South Carolina and the nation seemed deceptively simple. State and professional associations' curriculum standards and state accountability assessments had come into their own. Dialog and action was centered on alignment. If we could fine-tune the alignment of standards, assessments and instruction, the thought was, then we'd soon be first in the world in mathematics and science. (Well, actually, we were supposed to achieve that goal by the year 2000.)

The National Research Council's Committee on Science and Math Teacher Preparation (2001) speculated about the impact of newly released Technology Standards from the International Technology Education Association and placed "technology education on the same footing with science and mathematics education" (pg 1). Engineering Education standards simply did not exist. No footing was offered to engineering educators.

Those who saw natural connections and interrelationships between science, mathematics, engineering and technology organized their thought leadership under the ungainly acronym of SMET. Meanwhile, a storm was gathering in the form of growing economic prowess in places like China and India that would soon engage organizations like the National Governor's Association and the US Chamber of Commerce in conversations about and advocacy for what came to be called STEM Education, as a pathway to our own nation's economic prosperity and national security. (See References and Resources pages for links to further information.)

On one level, this conversation has simply moved the idea of fine-tuning the alignment of standards, assessments and instruction to the national level. We now talk and act on Common Core Standards and Multi-State Assessment Consortia. Perhaps if we could fine-tune the alignment of standards, assessments and instruction nationally (and toss in some technology and engineering for good measure), then we'll soon be first in the world in mathematics and science? (See, for example, the included Carnegie Corporation technical report entitled, *The Opportunity Equation – Transforming Mathematics and Science Education for citizenship and the Global Economy*.)

On another level, this trend toward STEM education begs questions about our traditional siloed approach to standards, courses, graduation credits and other organizing aspects of schools that separate science from math from engineering from technology. What might be is a very much more integrated approach to learning the important stuff and ways of thinking relevant to mathematics and science within the contexts of engineering and technology. SCCMS is planning to promote dialog about what might be through a statewide STEM Summit on August 1, 2011.

Trend 2 – Research-Based Instruction.

I had heard it said about 10 years ago, with the release of a book entitled *How People Learn: Bridging Research and Practice* (1999), that we've learned more about how the brain works in the past 5 years than we had learned in all of our prior history of study. No doubt that in the time that has passed since then we now know even more. Still, what we know in terms of how students learn mathematics and science has only just begun to impact classroom instruction. Instructional practices are still largely based on "tried and true" craft knowledge that often defies what learning research and student achievement evidence tells us about the effectiveness of these very practices.

Teachers of mathematics and science tend to teach in ways that mirror how they have learned. The rapidly expanding research base on how people learn presents an incredible opportunity to engage teachers in professional learning experiences using newly identified, research-based strategies to both increase their knowledge base and broaden their experience with strategies that help people learn. SCCMS is planning to promote this sort of professional growth for mathematics and science teachers through a pilot study exploring the use of research-based disciplinary literacy strategies to begin in the summer of 2011.

Trend 3 - The Ever Increasing Interactivity of Technology.

Ten years ago I did not text. I had no iPod or iPad. There was no Xbox, Wii or PlayStation in my home. Our Internet access was by dial-up phone modem. Today that is all different and compared to my children and their peers I am a digital dimwit. The implications in mathematics and science instruction for instant access to interactive digital information are staggering. As I type this report, I have run a Google search on "plate tectonics." This search yielded about 11,400,000 results in 0.25 seconds. My daughter's 8$^{th}$ grade physical science text book would be rather hard pressed to offer more than 3 paragraphs and 2 static pictures on the same topic. Many teachers, in spite of the ready presence of "smart boards" seem hard pressed to offer much more than the text, a videotape or two, and some paper and pencil "lab" activities as learning tools. This disparity between what is available for learning mathematics and science concepts in the world versus what is available in the school suggests that school mathematics and science instruction as we know it, focused on teacher delivery of content, is largely irrelevant. The relevant question for what might be is, "How do learners, with the aide of an expert facilitator, sort through vast quantities of available content to make meaning as they learn toward their civic, college or career needs?" SCCMS is exploring this question in partnership with SCDE in a "Digital Pilot" study of the use of laptops and iPads as learning tools in a handful of secondary schools.

## EFFECTIVENESS

If the primary mission for learning mathematics and science is to continue learning opportunities, offer access to career choices and prepare students for informed participation in civic life, then the measures of effectiveness that matter most ought to be related to these three outcomes. The evidence available, though anecdotal or correlative, suggests we fall short on all accounts.

The anecdotal data: Over the past 17 years that I have worked as a science and mathematics educator in South Carolina, I've been to countless meetings on college campuses, in schools, and in boardrooms. Through SCCMS, I have called together multiple regional and statewide meetings of educators, business and civic leaders. I cannot recall a single one of these meetings where the consensus…or even the minority opinion was that any more than a small fraction of graduates from South Carolina's K-12 schools were well-prepared for further studies, careers or civic discourse in STEM or any of its component disciplines. The Pollyanna in me is inclined to attribute some of this dissatisfaction to what I call "Socratic or Platonic Angst." Depending on which sources one taps, either one or both great thinkers are said to have lamented the sorry state of the younger generation of their time. Indeed it is easy to find similar laments expressed throughout human history. And, still there has been incredible progress in science, mathematics and related learning. So, maybe we adults are just predisposed to be down on the capabilities of our children even though they can program our DVD players and beat us at every videogame made in the past 10 years.

A sample of correlation data: Over the past 17 years, I have read dozens of reports and studies of student achievement and interest in science and mathematics. Most of these are international comparisons and some include state-by-state data. The most recent, a 2010 report from Harvard University's Program on Education Policy and Governance (included) shows South Carolina as ranking 11$^{th}$ in the nation in students' performing on the "advanced" level on a highly regarded mathematics assessment. Good news for us except that our 11$^{th}$ place score of 6.7% is less than 60% of top ranked Massachusetts at 11.4% and way below world leader Taiwan's 28%. So, if one assumes a correlation between performance on specific assessments and preparation for further learning, careers and civic engagement in STEM related content, then we have a ways to go to be considered as being as effective as the very best.

Causation? Given a general consensus of anecdotal and correlation data that identifies our state as being less effective than we might be in meeting our mission, it is reasonable to explore factors that we feel are causational. This takes us deeper into the lenses of our Theory of Action.

## CORE COMPONENTS

Author's note: The comments in this section refer primarily to state level leadership in mathematics and science. This includes everyone in general who is engaged in instructional improvement in these disciplines and singles out no one person, entity or association in specific. References to "we" and "us" refer to this broad and difficult-to-define community and suggest that one role for the South Carolina Department of Education (SCDE) is to clarify its own intentions as a leader in agenda setting for the improvement of mathematics and science instruction.

### I. Enabling Factors

**Standards** – Generally, the feeling among educators concerning state standards is that our current offerings are pretty reasonable. This faint praise is consistent with mixed ratings of our standards, at least in mathematics, by national experts like the Fordham Institute (2010). That said, mathematics moves toward the Common Core Standards and Common Core drafts for science are in development. We expect that consideration of Common Core science standards will be more contentious than that of English/Language Arts or mathematics.

If we accept the assertion that fine-tuning of the alignment of standards, assessments and instruction is the pathway toward becoming first in the world in mathematics and science, then we have quite a few more years in flux ahead of us. I am finding the assertion that fine tuning will lead to success to be increasingly questionable.

**Research** – We simply have no research agenda regarding ways to improve mathematics and science instruction as a state. This is not to say that research toward this end is not being done in South Carolina. Rather, as a state we have set no priorities for research questions we want answered. There are ways to set this agenda without additional cost to the state. One such way is to target Mathematics and Science Partnership (MSP) Competitive Grants toward specific research actions.

SCCMS and the $S^2$MART Centers have established a research agenda focused on triangulating schools' fidelity of implementation of instructional improvement strategies with stability factors and measures of student achievement in mathematics and science.

**Data** - Recently, at a national STEM education conference, I heard a speaker describe "Data-Driven Decision Making" as the four most meaningless words in education today. When it comes to mathematics and science instruction, we are awash in data. The having of data, however, yields little in understanding or improvement without a research agenda. What we often find in our own SCCMS/$S^2$MART Centers research is a two-fold challenge. First, the data everyone cares about are student achievement (largely PASS) measures and the student achievement data available are neither closely related to the instructional improvement work being done nor are they available to researchers in a timely manner. MAP data, while timelier, are less well-correlated to South Carolina Curriculum Standards, especially in science.

Rather than collect lots of data in hope that they might help us answer questions we may have some day, I propose that it is better to identify questions we have today and then set about tomorrow to collect the specific data we need to answer the questions we have.

**Planning** - We simply have no plan regarding ways to improve mathematics and science instruction as a state. That which happens as a result of SCDE initiation is based more on what funding sources allow than on what forethought would demand. This is not to say that there is no thought at all going on toward this end in South Carolina. Rather, it is to say that thought leadership is fragmented and too often driven by politics and policies instead of plans for systemic action.

**POLICY** – This is not an area where any of my colleagues or I claim expertise. As a general principle, policies that encourage the maintenance of individual silos for science, mathematics, engineering and technology are probably not going to be particularly helpful in about 10 years, when we realize the limitations of the standards/assessment/instruction alignment approach to accelerating student learning in math and science. Down the road awaits an impending "car wreck" when the standards/assessment/instruction movement and the STEM movement both gain sufficient speed to make their crossing paths a dangerous action.

FUNDING – We simply do not understand the full picture of funding available to support mathematics and science instruction in South Carolina Schools. We do know a bit about targeted sources and the comments below will focus solely on these.

In 1985, the Dwight D. Eisenhower Mathematics and Science Education Act amended the Elementary and Secondary Education Act of 1965 Act (Title II Part B) to provide funding specifically for professional development opportunities for math and science educators. The program distributed funds to the states and school districts solely for this purpose. These funds, in combination with the National Science Foundation's Statewide Systemic Initiative grants that created our statewide network of regional mathematics and science centers (originally known as "Hubs") drove much of the mathematics and science professional development activity in our state until 10 years ago.

The Elementary and Secondary Education was amended, yet again, in 2001 by the No Child Left Behind Act and replaced funds sent directly to all school districts for mathematics and science professional development with competitive grants available to limited numbers of schools through the US Department of Education's Mathematics and Science Partnership Program. Significantly, this change occurred with a coinciding emphasis on high stakes testing in language arts and mathematics and the end of the Statewide Systemic Initiative.

The comparison in Figure 2 below identifies the state and federal funding commitment directed at statewide support systems for school districts seeking to improve literacy (English/Language Arts and Reading), mathematics and science. Note that MSP funds identified only are those awarded as grants to

SCCMS as these were directed to support SCDE's statewide interest in instructional coaching.

*Figure 2. State and Federal Funding for Statewide Support Systems in English/Language Arts, Mathematics and Science*

| School Year | GIR Appropriation | SCRF | Math & Science Centers | MSP |
|---|---|---|---|---|
| | State of SC | Federal | State of SC | Federal |
| **2002-03** | $3,085,763.00 | $14,093,097.00 | $3,038,290.00 | |
| **2003-04** | $1,312,874.00 | $14,370,958.00 | $3,038,290.00 | |
| **2004-05** | $1,312,874.00 | $15,025,161.00 | $2,900,382.00 | |
| **2005-06** | $1,312,874.00 | $16,142,954.00 | $2,900,382.00 | $148,322.00 |
| **2006-07** | $1,312,874.00 | $16,142,954.00 | $2,900,382.00 | $822,388.00 |
| **2007-08** | $2,962,874.00 | $16,631,104.00 | $2,900,382.00 | $1,405,134.00 |
| **2008-09** | $2,790,346.00 | $6,400,393.00 | $2,731,493.00 | $1,895,548.00 |
| **2009-10** | $6,542,052.00 | | $3,576,000.00 | $1,150,001.00 |
| | | | | |
| **2002-10** | $20,632,531.00 | $98,806,621.00 | $23,985,601.00 | $5,421,393.00 |
| **Total State + Federal** | | **$119,439,152.00** | **$29,406,994.00** | |
| | | Reading allocation as a percent of Math and Science Allocation: | | |
| | | **406%** | | |
| | $103,706,361.00 | | $20,053,952.00 | $17,015,662.00 |
| | | | | |
| | | | | |
| | Sources: SC Budget bills, the SCRF Web page and SCDE budget records. | | | |

*NOTE: GIR = Governors Institute for Reading  SCRF = South Carolina Reading first*

What is significant, along with the constant and quite noticeable investment difference between the subject areas, is a trend not identified by these data. That is, South Carolina's overall investment in its statewide support system for school districts seeking to improve mathematics and science has actually decreased in two ways. First, is a decrease that results from the effects of time and funding stasis. South Carolina's initial annual investment in the Statewide Systemic Initiative in 1993 was $3.2 million. Today, based on a calculation tool developed by the American Institute for Economic Research, an equivalent investment would be approximately $4.8 million. Current projections funding of the statewide support system for the 2010/11 school year include approximately $3.5 million of state and federal funds. Second, funding sources currently used to maintain this statewide support system increasingly diffuse the focus of this system away from improving mathematics and, to a greater extent, away from improving science instruction.

Perhaps a statewide system of support is simply a quaint artifact of what was that is increasingly irrelevant to what might be? Authors from the Stanford Center For Opportunity Policy in Education (2010) and persistent trends in our state say otherwise.

## II. **A Statewide System of Support**

Our statewide system of support for mathematics and science, known variously as the "Hubs", the Mathematics & Science Regional Centers and now the Regional S$^2$MART Centers, was formed in response to some very persistent trends identified in the early 1990's as endemic to our state's school system. The purpose was not to make the causes of these trends go away, but rather to lessen their negative impact on student learning in mathematics and science.

Trend 1 - Clustering of Resources

We remain a state in which economic growth, income, informal education opportunities and other resources that promote interest and success and spawn innovation in mathematics and science are unequally distributed. Effective strategies to improve instruction and student learning often get stuck at the point of inception and must be reinvented repeatedly for lack of avenues for sharing.

Trend 2 - Small School Districts

We remain a state in which small school districts are numerous and simply do not have staff who can direct their full attention to mathematics and science. Recent funding difficulties have caused even large school districts to cut staff dedicated to the improvement of mathematics or science instruction. The School District of Greenville County, for example, recently eliminated two of four central office positions focused on these disciplines and all science lab instructors from their elementary schools.

Trend 3 - Unstructured Communication

We remain a state in which school districts simply have too many directives to attend to and few good ways to keep current in fast changing area like mathematics and science. Professional conferences, once a staple of those seeking to learn and share, such as those offered by the South Carolina Science Council and the South Carolina Council of Teachers of Mathematics, have seen significant decreases in attendance due to funding difficulties. Educators cannot get to expertise. It must come to them and they must learn new ways to sustain their learning without leaving home.

What a statewide system of support does is bring to school districts that which they have not the capacity to consistently seek out for themselves. Some examples of how our statewide system of support has helped our schools overcome negative impacts of these trends in mathematics and science include:

- The widespread use of exemplary curriculum materials developed through our LASER initiative with the NSRC (1998 – 2003).
- The increase in school level capacity for instructional improvement and information sharing lead by instructional coaches (2003 to present).
- The increased focus on site-based professional learning promoted through every S$^2$MART centers program (2003 to present).
- The increased networking of Title 1 schools through LeadS$^2$MART (2009 to present).

## III. Continuous Improvement Foci

### Engaged School Community (STAKEHOLDERS and STUDENTS AFFECTED)

What we know about STEM education is that it is relevant to all of South Carolina's school children. As previously stated, the content and ways of thinking associated with these disciplines are known to be relevant to continued learning opportunities, career choices and informed participation in civic life.

Recognition of this importance for everyone from future farmers to future automotive engineers has brought a multitude of potential players to the mathematics and science education improvement table. Within our state are perhaps 1000's of opportunities for STEM learning sponsored by businesses, industries, institutions of higher education, technical colleges, museums and more. As an example of the potential and possibilities, a recent survey within Clemson University identified over 100 projects and programs with a STEM education outreach component.

What seem to be missing in maximizing the potential impact of such opportunities are two things: coherence and student engagement.

Coherence: Opportunity is good. Hundreds of opportunities are even better. Thousands are even more so. Or maybe not? Offering lots of programs to improve STEM education is a wonderful legacy. We can say we tried really hard. It is not, however, leadership. Leadership would be to identify a handful of ways that we, as a state, prefer to address the STEM mission and engage the 1000's…or at least a few hundred of them in aligning their efforts. Imagine, for example, beginning teachers who knew that there was a coherent system of formal and informal learning experiences waiting for them as a pathway to their continuing growth in science and mathematics throughout their professional life. Currently, awareness of and access to such opportunity is haphazard at best.

Student engagement: South Carolina is not Missouri or Kansas. But, its people are not all that much different. If we can accept the 2007 results from a Public Agenda study based in the Midwest as a reasonable measure of typical American attitudes, then there is ample reason to believe that South Carolina's students and their parents largely do not see STEM studies and careers as relevant to them. What does this mean for us in achieving our mathematics and science mission if we have engaged businesses, industries, institutions of higher education, technical colleges, museums and more…and yet not but a minority of the very people who we hope will benefit from STEM education efforts?

### Coherent & Viable Curriculum

If there is any more misunderstood word in education today than curriculum, I do not know it. From the perspective of the $S^2$MART Centers Theory of Action, when we speak of a coherent and viable curriculum, we refer to the curriculum enacted in school classrooms. Coherence describes instruction such that what is taught in any classroom on any day is relevant to learners as part of a ongoing storyline for meaning making in mathematics and science. In other words, what is taught makes sense in the disciplines

of mathematics and science and to the learner. Viability describes the availability of resources to enable the curriculum to be enacted as intended.

What is safe to say about coherence in mathematics and science is that curriculum standards have driven us to greater consistency in instruction over the past several years. Gone are the days when every teacher in every elementary grade taught units on dinosaurs, plants and weather for science. This consistency can be helpful to students in guaranteeing them learning opportunities and mind numbing when superficial "covering" of standards is given priority over meaning making. We know all too often from our experiences with schools that many educators struggle with artful coherence in mathematics and science. Where the $S^2$MART Centers are at their best is in functioning as a statewide system of support that builds the capacity of instructional leaders to artfully align standards, assessments and available resources. This $S^2$MART Centers' role also plays to viability.

What we have known for many years is that the science curriculum at the elementary grades is largely unviable without persistent external support. School systems simply do not assign sufficient resources, especially instructional time, for elementary science to be offered in a consistent and coherent manner. There have been brief interludes of success in our persistent external support as evidenced by growth in $4^{th}$ and $8^{th}$ grade NAEP scores from 2003 to 2007. (See Accelerated Student Learning below.) The ongoing challenge to viability of the science curriculum is availability of instructional time at the elementary level.

While I could speculate further on viability of science at other levels and mathematics at any level, I would suggest instead that this is a fertile area for research, particularly as we implement the Common Core Standards in mathematics. It would be good to know what it takes for the curriculum suggested by these standards to be viable in South Carolina's schools.

### Assessment for Learning

Assessment for learning refers to the sorts of measures that teachers make on a daily or periodic basis to help inform their instruction. PASS is not an example of assessment for learning. MAP may be and isn't always. Much of what we think of in this realm is teacher-driven and may include student portfolios or notebooks, performance assessments and even more traditional quizzes and tests.

What is safe to say about assessment for learning in mathematics and science instruction is that it is in its infancy. Over the past decade we have seen and promoted growth in the use of classroom assessment tools, analysis of MAP data and development of teacher professional learning teams focused on the examination of student work samples.

I would suggest that this is also a fertile area for research as well. It would be good to know more than anecdotally the state of our schools' capacity to assess student learning in ways that can more immediately bring coherence to curriculum and instructional choices.

## Instructional Materials Support

Instructional materials support is really all about viability of curriculum. Teachers need appropriate instructional tools to enact mathematics and science curricula. They also need training to make good use of the tools. Generally, our experience in schools suggests that teachers are more likely to have adequate tools for teaching mathematics and science than they are to have adequate training in their use.

From 1998 through 2003 the regional centers, then known as "Hubs," committed extensive resources toward preparing and supporting teachers to use science kits as tools to enact curriculum. Data we compiled in 2002 indicated that nearly 66% of the K-8 students in seven reporting "Hub" regions were engaged in science learning experiences supported by instructional kits. This effort demonstrated what a focused statewide commitment to viability of curriculum could accomplish. It further lead to ongoing financial support for schools implementing inquiry-based instructional materials in science. (See General Appropriation Act, 2009 S.C. Acts 23, Proviso 1.34)

Our state's instructional materials support efforts were studied and adapted by the Alabama Department of Education and developed into the nationally recognized Alabama Math, Science, and Technology Initiative. That could have been us. Indeed, ten years ago we had several regional instructional materials support centers serving schools across our state. All but a very few are now defunct.

Our experiences with this focus area also led organizations like South Carolina's Leaders in Mathematics Education (SCLME) to seek funding for inquiry-based instructional materials to facilitate enactment of the mathematics curriculum. This effort stalled with the recent economic downturn.

It would be good to know more than anecdotally the current state of our schools' capacity to select and support curriculum materials that make our mathematics and science curricula viable. This is another area ripe for research.

Over the past several years, state led efforts to promote effective instructional materials support have yielded to strategies to directly grow the instructional capacities of teachers. Largely, this is a good shift.

## Powerfully Prepared Teachers…and Administrators

Since its inception, our statewide system of support for mathematics and science instruction has had a focus on building leadership capacity in teachers and administrators. Our initial efforts were very traditional: summer or school year leadership workshops with occasional follow-up sessions. Anecdotally, we know that many participants in these leadership institutes did take on leader/mentor roles in their schools and districts. We also know that after 10 years (1993 – 2002) of this sort of leadership development coupled with tens of thousands of hours of workshops, we could find no direct evidence that this rather haphazard approach to teacher support led to any impact on our state's measures of student learning. Still, a study completed by the Wisconsin Center for Education Research (date unknown) indicates several positive results on NAEP achievement. Perhaps a more focused approach to developing

teacher competencies in mathematics and science would have yielded even better results?

In late 2003, we turned our attention to schools rather than individual teachers as units of change with a focus on instructional coaching. The premise is fairly simple. A powerfully prepared instructional coach, supported by a knowledgeable administrator, works side-by-side with teachers every day to improve instruction. Improved instruction leads to accelerated student learning. Indeed our analysis of the impact of instructional coaching on student learning as measured by PACT test results has showed promise. For example:

> In our 2009 study of middle school based instructional coaches, we found that 70.8% of grade levels impacted by science coaches achieved "safe harbor" gains (an increase of 10% or more of the previous year's results) in students scoring Proficient or Advanced in two consecutive years. In mathematics, 33.3% of grade levels impacted by mathematics coaches were able to achieve "safe harbor" gains at this level of student performance. During this same two-year time period, the state as a whole made no "safe harbor" or better gains in any middle grade mathematics levels ($5^{th}$-$8^{th}$).
>
> In 2010 we attempted to bridge the PACT/PASS gap in our instructional coach evaluation. We examined data from only those middle schools where coaches completed their full training program. These schools offer us a challenging analysis with three years of data on the PACT side and two on the PASS side.
>
> MATH (9 impacted grades)
>
> 17.9% - Average increase in Advanced/Exemplary from PACT 2006 to PASS 2010
>
> 2.3% - Average increase in Below Basic/Not Met from PACT 2006 to PASS 2010
>
> SCIENCE (11 impacted grades)
>
> 11.8% - Average increase in Advanced/Exemplary from PACT 2006 to PASS 2010
>
> 11.9% - Average decrease in Below Basic/Not Met from PACT 2006 to PASS 2010

The full reports of our iCoach data analysis are available on request.

Instructional coaching, however, is in decline as the recent economic crisis has forced most schools to choose between the having of teachers and the having of professional learning support for them.

Given what we know about teaching as a profession, it is unreasonable to assume that ongoing improvements in preservice preparation will ever lead to teachers who are prepared for a lifetime of teaching. Thus, it remains imperative for some sort of statewide leadership in the setting of directions for continuous learning in mathematics and science. Here are some trends to be mindful of in considering future directions.

Trend 1 – Teachers as informed consumers.

Trends in the development of nationally implemented standards and assessments, coupled with inexpensive technology tools and mountains of easily accessible information, suggest a new marketplace for instructional materials to be developed that are far beyond textbooks and farther beyond what individual mathematics and science teachers or small groups there of can create in their spare time. This suggests that

helping teachers learn to create lessons is a quaint and soon to be outdated notion. Powerfully prepared teachers and administrators must instead learn to be good consumers of instructional materials; meaning they can make good selections based on criteria relevant to the characteristics of their disciplines and the likelihood of accelerating student learning.

Trend 2 – Teachers as models and mentors.

Given the ease of access to content, it is insufficient for teachers to simply be presenters of the same. Powerfully prepared teachers must model how their disciplines make and make sense of content and mentor students as they learn to do the same.

Trend 3 – Teachers as team members and mentors.

In nearly every conversation I have with business/industry officials, they repeat the need for students to learn to work as teammates. Teachers can neither model nor mentor in that which is unfamiliar to them. Powerfully prepared teachers and administrators must instead know ways to learn and work together that get around or break down structural barriers in schools that inherently keep them in isolation.

## IV. Improved instruction

> *Most administrators don't have a good understanding of what standards-based math instruction should look like. They are more concerned about what page teachers are on and how the benchmark tests and/or MAP scores look.* (SCLME member)
>
> *I would love for you, or someone in your group, to stop by and record some master lessons. We could easily create a library of lessons and assessment strategies that could be accessed by students, parents, and teachers.* (Middle School Principal)
>
> *How do we get some kind of agreement about what "good" might look like in instruction…* (SCDE staff member)

When it comes to mathematics and science instruction, the question on the minds of many seems to be, "Do we even know what we want to see?" The quotes offered above seem to suggest that the answer is a resounding, "NO!" On the other hand, when I ask this question of instructional leaders in our state and of colleagues around the country, the response is always consistent; it matches descriptions of good instruction identified by mathematics and science professional organizations and supported by research on how students learn.

This suggests that what we face in South Carolina's schools when seeking to improve instruction is not so much a vision gap as it is a knowing-doing gap. Knowing-doing gaps can be bridged when the vision is constantly and consistently presented, support is provided for those in the process of learning and applying new knowledge about effective instruction, and evidence is generated that the doing is working. All these are important roles for SCDE.

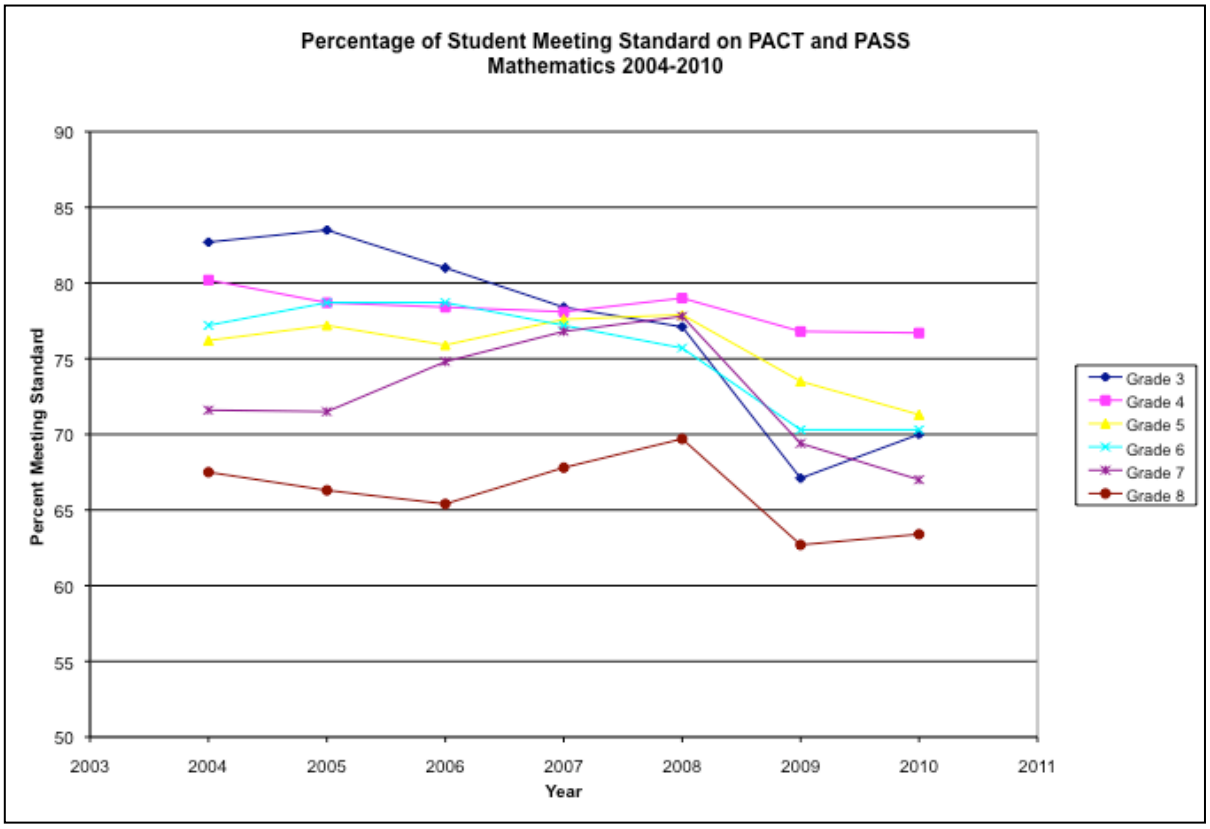
Internal studies suggest instructional coaching leads to increased observation of strategies identified as indicators of improved instruction (Wicker, 2006). External studies of coaching and other strategies intended to improve instruction, including the preservice level, would be helpful in identifying pathways for statewide efforts to turn knowing into doing.

## V. Accelerated Student Learning MEASURES

The measure of student learning that matters the most to the majority of our stakeholders is the accountability measure; PACT/PASS. It is important to remember the limitations of these measures and to avoid using those limitations as excuses to ignore results we don't like. PACT/PASS scores are much like time measures for a 40-yard dash. They tell us something about the "speed" of learning of one group of students as compared to the next and nearly nothing about the "runners" or their "training."

Mathematics: PASS/PACT matters in mathematics where learning in grades K-8 is foundational for advanced studies in high school and beyond. One can hardly look at these data and claim consistency in acceleration of student learning even if limiting examination to PACT data alone. (Longitudinal interpretations are difficult to make given the switch from PACT to PASS after 2008. Meeting standard appears to be a greater challenge on PASS in mathematics.) National Assessment of Education Progress (NAEP) data show a similar stagnation of student performance at grades 4 and 8 during the 2003 through 2009 assessment period.

*Figure 3 Longitudinal Data for Statewide Student Learning - Accountability*




A clear and persistent trend of concern is the lesser performance of middle grades students than of those in elementary grades. More disturbing is the deceleration of learning in Grade 3 in state measures.

*Figure 4 Longitudinal Data for Statewide Student Learning – NAEP Mathematics*

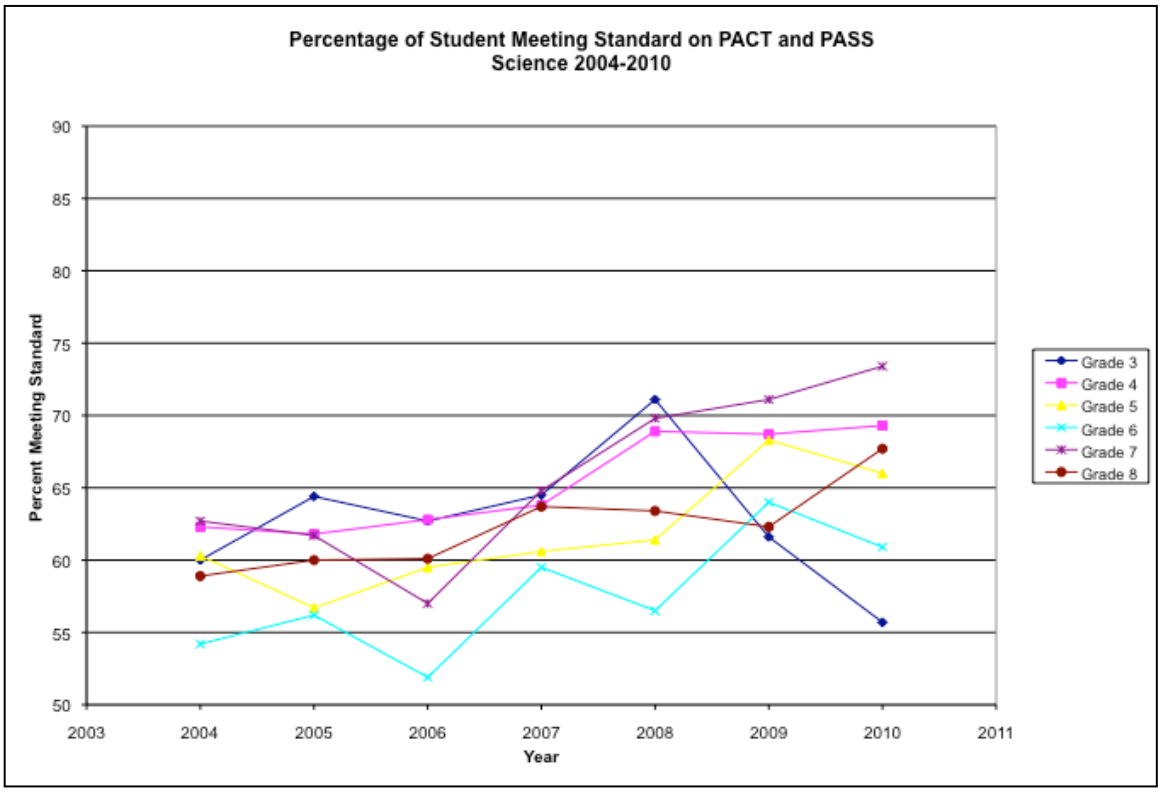
| | Grade 4 | | Grade 8 | |
|---|---|---|---|---|
| | Nation | SC | Nation | SC |
| 1992 | 219 | 212 | 267 | 261 |
| 1996 | 222 | 213 | 271 | 261 |
| 2000 | 224 | 220 | 272 | 265 |
| 2003 | 234 | 236 | 276 | 277 |
| 2005 | 237 | 238 | 278 | 281 |
| 2007 | 239 | 237 | 280 | 282 |
| 2009 | 239 | 236 | 282 | 280 |

Conventional wisdom has it that the drive to ensure success in reading at the early grades has negatively impacted the amount of instructional time available for learning in other disciplines.

A more recent and dramatic deceleration of science achievement in Grade 3 (see Figure 5) suggests that we ought to find out whether conventional wisdom is reliable, particularly before any new emphasis is placed on early reading. It is simply shortsighted to increase opportunity to learn in one discipline by decreasing it in others.

Science: It is easier to look at the data in Figure 5 and claim some consistency in acceleration of student learning in science even without examination of PACT data separately from PASS. Also, these data do not suggest a significant different in knowledge required for meeting standard on PASS as compared to PACT for science.

*Figure 5 Longitudinal Data for Statewide Student Learning – Accountability Science*



We have, however, no South Carolina NAEP data for science past 2005 and this makes triangulation of accountability measures and wisdom from the field regarding student learning in science a rather difficult task.

*Figure 6 Longitudinal Data for Statewide Student Learning – NAEP Science*

| | Grade 4 | | Grade 8 | |
|---|---|---|---|---|
| | Nation | SC | Nation | SC |
| 1996 | | | 148 | 139 |
| 2000 | 145 | 140 | 148 | 140 |
| 2005 | 149 | 148 | 147 | 145 |

I would encourage SCDE to consider investment in another external measure of student learning in science as a way to help assess longitudinal performance trends across the PACT/PASS gap.

Big Picture: So where do we go with accountability measures? Analysis of student responses to individual test items can give us better information about the math and science that students are and are not understanding. Having this information and having it in a timely manner may improve the ability of those responsible for the professional learning of teachers to better target the training opportunities they provide. And, this begs us to ask questions about the relationship of student performance on accountability assessments to our mission. In what ways does PACT/PASS serve as a measure of preparation of students for continued STEM learning opportunities, career choices and informed participation in civic life? In what ways does it not? Is alignment enough? These are vision questions and they are not questions my colleagues and I have heard being pondered in recent years outside of a very small circle within the SCDE.

To be blunt, the infrastructure for mathematics and science within the SCDE is crumbling just like it is in our state's schools. SCDE has no specified leaders in mathematics or science anymore and those with vision have no platform for sharing it. This is all happening at the same time the $S^2$MART Centers are being pulled from their historic mathematics and science focus due to funding source expectations. It takes no vision to keep the mathematics and science "trains" running as long as no one asks why they run or where they ought to carry us.

**What Might Be**

As I have previously stated, I am increasingly questioning the limitations of the alignment of curriculum standards, assessments and instruction as the pathway to an accelerating student learning. While I am confident that such alignment would lead to an boost in student learning, I am concerned that it will be too little and too late. Factors that limit student learning, from subject silos to agrarian schedules to readiness for school based on date of birth, don't go away with better alignment. A fundamentally obsolete structure would still underpin even the very best of mathematics and science instruction.

I understand why SCDE and the many individuals and organizations interested in improving STEM education must focus on alignment. We need to do this for the

students in schools today. In doing so, we should be mindful of lessons learned from our own work in South Carolina's schools and from the work of others. One size of effort does not fit all when it comes to improving schools as they are. See, for example Mourshed, et al., 2010. It would help us to know with certainty where our schools and districts are in the continuum of poor to great in mathematics and science. PACT scores are not enough of a measure.

We owe it to our state to experiment a bit with options that might prevent the complete obsolescence of public education. Perhaps what might be lies waiting in charter or other sorts of experimental schools yet to be.

The relevant question for what might be is this, "If the only givens were learners and learning, what would we do with mathematics and science instruction to facilitate learning opportunities, career choices and informed participation in civic life?"

On behalf of all the individuals and organizations whose ideas are represented in this report, I am hopeful that we'll all work together toward figuring this out!

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