Science Framework and Standards

A SPECIAL INTEREST GROUP

2013 Math and Science Partnership Learning Network Conference

Implementation: From Vision to Impact

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Contents:

Description: Discussion of opportunities, challenges and specific strategies related to pursuit of the vision outlined in the NRC *Framework for K-12 Science Education* and the corresponding learning goals in the *Next Generation Science Standards*.

Moderator:

Philip Bell

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Co-PI, Research+Practice (R+P) Collaboratory

Cover: Group discussion

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About This Summary

This document focuses on one of the Special Interest Group (SIG) sessions at the 2013 Math and Science Partnership Learning Network Conference (LNC). The intent is to provide a summary of the session, highlighting participant discussion.

A descriptive list of all SIGs, convened based on participant interest, may be found at the 2013 LNC site on MSPnet (see URL at right). Original PowerPoint slide presentations are also available on MSPnet.

The LNC Online:

http://hub.mspnet.org/index.cfm/msp_conf_2013

Readers interested in pursuing any of the plenary session presentations from the 2013 LNC are encouraged to access MSPnet to find a document summarizing these sessions, full video recordings of the presentations, the original PowerPoint presentations, and detailed speaker biographies. All abstracts submitted for breakout sessions during the conference are also available on MSPnet.

Next Generation Science Standards (NGSS) for Today's Students and Tomorrow's Workforce: The New Consensus Vision for K-12 Science Education

Opening Thoughts

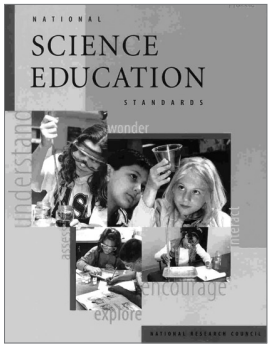
Philip Bell launches the discussion with a quick overview of the science standards and some of the bigger changes in the framework so that session participants share an understanding of the focus of this discussion. He observes that a host of challenges, opportunities, and needed strategies are emerging that are tied to this new vision and set of standards.

A version of this happened in the 1990s when two organizations came out with slightly competing visions. Depending on which your state adopted, Bell observes, things veered off in one direction or the other.

National Policy Documents from mid-1990s

1993

1996

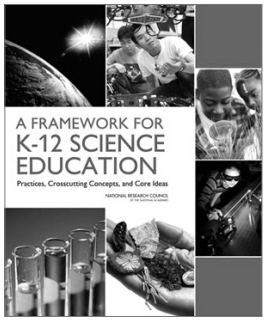


As Common Core Standards came along, the Carnegie Corporation thought it a good time to energize science education with a new set of standards and a new vision, and decided to try to create one vision that would serve all well. The National Academy of Sciences convened a committee, which Bell served on, and after 18 months *A Framework for K-12 Science Education* came out in July 2011 in its final form.

The three dimensions underlined in the quote below are at the heart of the vision leading to

Next Generation Science Standards

- "The framework is designed to help realize a vision for education in the sciences and engineering in which students, over multiple years of school, actively engage in **science and engineering practices** and apply **crosscutting concepts** to deepen their **understanding of the core ideas** in these fields."
- Framework is guiding the development of *Next Gen Science Standards*. Twenty-six states are leading the effort; almost all states are directly involved.



Online: tinyurl.com/ScienceFramework

THE NATIONAL ACADEMIES

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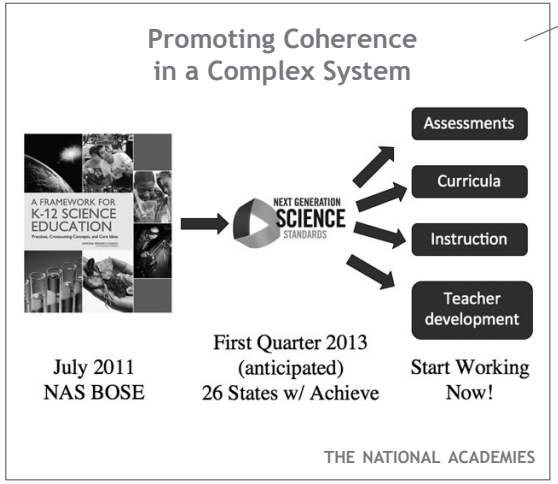
All young people should be able to decide their futures.

Philip Bell



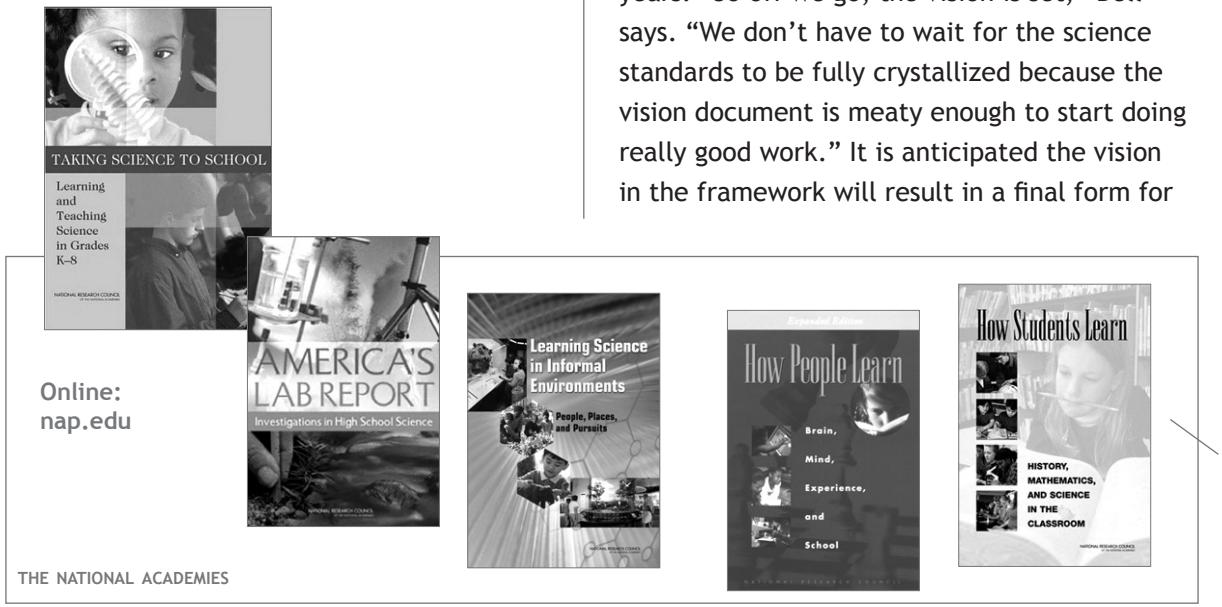
the development of the standards, Bell notes. Once the National Academies did this work, Achieve, which had been doing work in the Common Core arena previously, stepped in to coordinate the process around the development of *Next Generation Science Standards*. Twenty-six states around the country signed on to be lead states, and almost all states have been fairly heavily involved, Bell reports. In a series of meetings with state science supervisors over the last year and a half or so, there are usually 44 or 45 states in the room with their teams, thinking about implementation of the new science vision.

Many districts are beginning to orient their teachers, and individuals are being tapped to engage with higher education faculty around aligning project work to the standards, which will ease the work of teachers in the coming years. "So off we go, the vision is set," Bell says. "We don't have to wait for the science standards to be fully crystallized because the vision document is meaty enough to start doing really good work." It is anticipated the vision in the framework will result in a final form for the standards, hopefully in March, he reports. In what Bell describes as a "model of transparency," the process has been open to allow the field to give feedback, leading to refinements and revisions based on that feedback.

The new vision calls for new assessments. Martin Storksdieck, from the Board on Science Education at the Academies, talked earlier at this LNC about a committee that is doing a vision-level document regarding what those assessments should look like. At the same time, Bell notes, most people in the field of curriculum development have said the vision is different enough to warrant a whole new set of curriculum development efforts. Some retooling can be done of the inquiry-based materials, he observes, but it calls for a deep revision that would be better off with a restart.

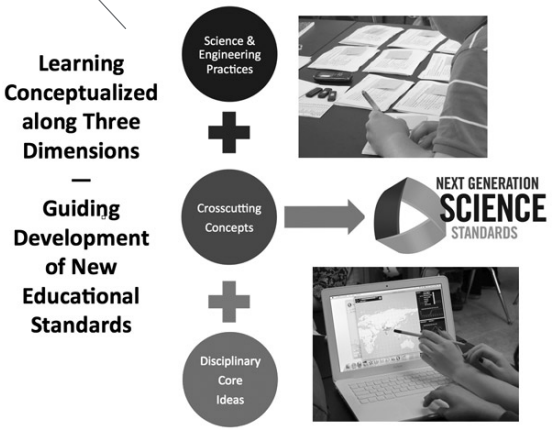
It also has instructional implications as well as teacher preservice and inservice implications, not only around the substance but also in some of the assumptions. For example, Bell says, if you have the same core idea developing across K-12, organizing professional development across grade bands makes great sense. For example, if you want kids to be learning about heredity in second grade and to deepen that by the time they get to biology in high school, you want that coordination to be in place.

To the degree possible the framework committee was leveraging the best research foundation, drawing on consensus reports related to science and teaching. Each is a synthesis of about 1,200 peer-reviewed studies in a



particular direction such as out-of-high-school, high school lab, or K-8 science instruction. As a result, when people ask whether this effort is research-based, there is a lot that could be said, Bell notes. This is an important moment in the adoption process, he notes. Some groups are critical of the vision and it is important to be able to point to this empirical research base as a rationale.

The slide below depicts the core image of learning in the document, showing the three dimensions. The first is Science and Engineering Practices, the disciplinary ways in which scientists and engineers do their knowledge work, and it is at the core as the first dimension. The second is Crosscutting Concepts, big, major themes or ideas that show up across disciplinary fields of the sciences (e.g., structure and function, energy conservation). The third, Disciplinary Core Ideas, is the content knowledge dimension. The three dimensions come together to create performance expectations in the form of the standards being created.

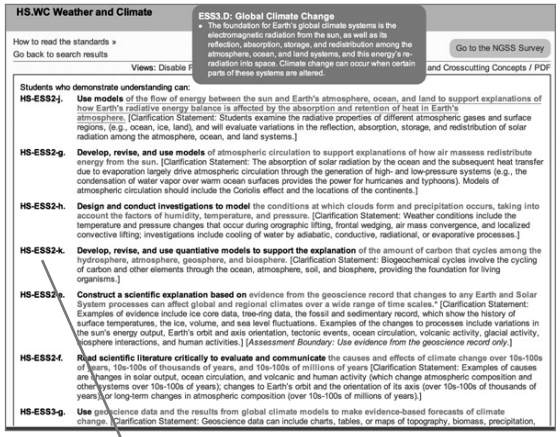


Standards are taking the form of performance expectations defined through combinations of elements of the three dimensions that progress across grade levels.

At right is an example of what those standards look like from the January release of the last public version of the document. This is the Weather and Climate High School Standard. We haven't seen standards like this before, Bell observes, noting that these contain a lot more detail and information in an effort to hold closely to the vision. Each paragraph is a performance expectation that relates to accomplishing that standard, indicating what students would be doing to demonstrate their understanding of that particular learning goal. The attempt is to highlight the three dimensions, so they are color coded in the text (i.e., blue text is practice-related ideas). Each takes two practices, points to a disciplinary core idea, and connects to a cross-cutting concept.

Each of these have been getting a lot of feedback, Bell reports, both to clarify and to draw boundaries (e.g. "You can go up to this point, but don't go past this point."). Part of what has happened in the past, he explains, is "scope creep" in learning because of the way things are written and then get interpreted either narrowly or broadly. A good part of the discussion has been about what is base science literacy for all citizens, where you draw the line, and where you go above and beyond.

What is not shown here that is in the web interface is that it links directly back into the



HS.WC Weather and Climate

How to read the standards »
Go back to search results

Go to the NGSS Survey

Views: Disable F ... and Crosscutting Concepts / PDF

ESS3.D: Global Climate Change
- The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space. Climate change can occur when certain parts of these systems are altered.

Students who demonstrate understanding can:

HS-ESS2-j. **Use models** of the flow of energy between the sun and Earth's atmosphere, ocean, and land to support explanations of how Earth's radiative energy balance is affected by the absorption and retention of heat in Earth's atmosphere. [Clarification Statement: Students examine the radiative properties of different atmospheric gases and surface regions, (e.g., ocean, ice, land), and will evaluate variations in the reflection, absorption, storage, and redistribution of solar radiation among the atmosphere, ocean, and land systems.]

HS-ESS2-g. **Develop, revise, and use models** of atmospheric circulation to support explanations of how air massess redistribute energy from the sun. [Clarification Statement: The absorption of solar radiation by the ocean and the subsequent heat transfer due to evaporation largely drive atmospheric circulation through the generation of high- and low-pressure systems (e.g., the condensation of water vapor over warm ocean surfaces provides the power for hurricanes and typhoons). Models of atmospheric circulation should include the Coriolis effect and the locations of the continents.]

HS-ESS2-h. **Design and conduct investigations to model** the conditions at which clouds form and precipitation occurs, taking into account the factors of humidity, temperature, and pressure. [Clarification Statement: Weather conditions include the temperature and pressure changes that occur during orographic lifting, frontal wedging, air mass convergence, and localized convective lifting; investigations include cooling of water by adiabatic, conductive, radiational, or evaporative processes.]

HS-ESS2-k. **Develop, revise, and use quantiative models to support the explanation** of the amount of carbon that cycles among the hydrosphere, atmosphere, geosphere, and biosphere. [Clarification Statement: Biogeochemical cycles involve the cycling of carbon and other elements through the ocean, atmosphere, soil, and biosphere, providing the foundation for living organisms.]

HS-ESS2-e. **Construct a scientific explanation based on** evidence from the geoscience record that changes to any Earth and Solar System processes can affect global and regional climates over a wide range of time scales.* [Clarification Statement: Examples of evidence include ice core data, tree-ring data, the fossil and sedimentary record, which show the history of surface temperatures, the ice, volume, and sea level fluctuations. Examples of the changes to processes include variations in the sun's energy output, Earth's orbit and axis orientation, tectonic events, ocean circulation, volcanic activity, glacial activity, biosphere interactions, and human activities.] [*Assessment Boundary: Use evidence from the geoscience record only.*]

HS-ESS2-f. **Read scientific literature critically to evaluate and communicate** the causes and effects of climate change over 10s-100s of years, 10s-100s of thousands of years, and 10s-100s of millions of years [Clarification Statement: Examples of causes are changes in solar output, ocean circulation, and volcanic and human activity (which change atmospheric composition and other systems over 10s-100s of years); changes to Earth's orbit and the orientation of its axis (over 10s-100s of thousands of years) or long-term changes in atmospheric composition (over 10s-100s of millions of years).]

HS-ESS3-g. **Use** geoscience data and the results from global climate models to make evidence-based forecasts of climate change. [Clarification Statement: Geoscience data can include charts, tables, or maps of topography, biomass, precipitation,

Excerpt:

HS-ESS2-k. **Develop, revise, and use quantitative models to support the explanation** of the amount of carbon that cycles among the hydrosphere, atmosphere, geosphere, and biosphere. [Clarification Statement: Biogeochemical cycles involve the cycling of carbon and other elements through the ocean, atmosphere, soil, and biosphere, providing the foundation for living organisms.]

(Bold text at the beginning of the paragraph is blue in the original, indicating a practice-related idea.)

Premises

• It is difficult at the moment, with NCLB and math and English getting as much attention in our learning environments as they are, especially at the elementary level. The vision is premised on having time for science. It is premised on doing some of your literacy in the science area. It is premised on the cumulative learning gains that happen when you have kids doing a coordinated thing across grades. That is a conjecture. Until accountability shifts, it is not exactly clear how systems are going to organize to these learning goals. • Philip Bell

Group discussion

framework, Bell explains. The framework laid out the disciplinary core ideas and the practices and crosscutting concepts. As you float over a piece of text online, it brings up the background information in the framework, linking the two documents. "The standards themselves don't carry the vision for science education." Bell notes, "It is really in the framework, so the two documents need to travel together because they are the hand and glove image of how to bring the field forward."

Group Discussion

Pouring Concrete vs. Testing Hypotheses

• The job that has been done in trying to put all of this together is kind of breathtaking, but I have some concerns. I think of it as the difference between a hypothesis and a law. Some of the changes I would put in the category of hypotheses. For example, some of the placement of learning goals are different from what we are used to and are pretty challenging. I've looked mainly at the elementary section and there is the idea, for example, that you can teach students that sound is a wave in fourth grade. There is even the idea, which I am supportive of, of the full integration of engineering and science education. It is a terrific idea, and it is what we do at Stevens, where I work, but how to do it is a whole other thing.

What I worry about is that in the rush to turn the standards interpretation of the framework into assessments at the state level, the statements in there won't be hypotheses to be tested, from which we will gather information to decide whether kids can really do this, how they can do it, and refine it. Instead, they will quickly be turned into consequential assessments. In the rush to assess everything, we will be taking what could be a document for a whole lot of research and development and refinement and turning it into something where the concrete will get poured way before it ought to get poured. • Participant

• This is certainly true to a healthy extent. We've leveraged what research literature was there to try to identify particular learning goals. At the same time it is a document that is supposed to serve us for ten to fifteen years as a vision to quest after, so it has to have some healthy ambition to it in terms of what we are asking of the system and of our learners. We were weighing decisions about introducing waves as an important idea in the physical sciences. We don't have deep literature on that, but we think you can start to

get things to happen at the elementary level that build from there. So there are conjectures in play that will, at some level, organize research to then see if it is actually possible. Regarding the threat of assessment jumping too early, I think we should all speak to the people involved in the assessment part to point them to areas of the learning goals that are more directly grounded in prior research and not as conjectural. • Philip Bell

The Time and Volume Issue

- There is the volume issue. I know they made an attempt to cut back, but it is still a lot. To fully engage in the practices in the way it is envisioned takes a lot of time to reach that level of depth and really work it though with kids in the classroom. • Participant

- The committee worried about these issues through the framework-setting moment. We actually don't know what the instructional time implications are of the full set of standards, or what it would take to get a student to the point where they could do the full set. Historically there is the mile-wide, inch-deep problem in science education. It is a struggle to get to less as a field. Almost every organization shows up to say it feels under-represented and wants to add, not subtract content. Science is such a multifaceted, broad set of fields and sub-fields, and there are good arguments to include all sorts of things. The open process did what it could to try to orient and relate to scientific literacy at this moment in history. So, for example, climate change got built in at a much higher level than it had in the mid-1990s for obvious reasons. • Philip Bell

Elementary Teachers' Science Proficiency, PD, & Resources

- Coupled with what has been said about time for science in elementary school is the limited proficiency in science of the elementary school teacher. For elementary teachers, reading some of this information is like reading Greek. They have no idea what that statement meant because they don't have the background knowledge. So we are fighting two very prominent factors that need to be overcome that will not be overcome any time soon. • Participant

- I think the grade level banding is so helpful. In New York, the teachers want a kit: "Give me everything I need to teach this." We haven't been able to use kits from Berkeley or kits from Virginia because they didn't match our standards, or we taught electrical circuits at fourth grade and this is meant for third grade. I'm excited about that grade level commonality and consistency because I think it will help open up the resources for elementary teachers. • Participant

- It will be similar to what happened in the mid-1990s. When those learning goals got set,

Caveat Regarding Aligned Curriculum

- Stephen Pruitt is coordinating the Achieve process for the standards. He received a request from a prominent curriculum development shop before the first draft of the standards became public, basically asking, "Can we use your logo because we want to say that we're aligned." Maybe if you were generous you could say they were aligned to the framework. I hope somebody is going to be the arbiter of alignment around curriculum in a way that hasn't happened historically. Otherwise we are all going to be left to our own internal process to figure out what is aligned to the vision. Until there are resources and incentives to do deep curriculum development moving towards the standards, it won't happen. • Philip Bell

Concern: Rigidity Instead of Fluidity

• Just a quick comment about this idea of how the practices get interpreted. I worry that the way in which the performance standards were formed will do the opposite of what you were saying in terms of fluidity and interdependence. It seems a bit arbitrary in terms of which content standards are connected to which practice. To me, these are examples of how one might engage simultaneously in the practices and in the standards, but they are just examples. What I worry is that they are married in a way that becomes rigid instead of being seen as examples, and that the coherence of the practices get lost in the performance standards. • Participant

Group discussion

all sorts of professional development resources and very specific things came into play to help teachers understand the specifics of content knowledge. The same thing will happen again, maybe through curriculum that actually does a good job of rendering learning experiences that move towards the goals. • Philip Bell

Crosswalk Between Math, Science, & English Practices

• Are you aware of anybody attempting to do any kind of crosswalk between the Common Core Math Standards, particularly the practices, and what we are seeing in the framework? Especially at the elementary level, that is really important. • Participant

• There are groups trying to figure this out, especially at the elementary level. There is unprecedented opportunity in the policy documents to make the life of a teacher more simple. There are ambitious learning goals in each of the documents—math, ELA, and science—but practices are shared at a deeper level than we have ever had before. Evidence-based argumentation shows up across all three documents. It is in disciplinary-specific ways, but there are general things that teachers can learn and then nuance to the disciplinary specifics.

Modeling using mathematical representation, that dance back and forth between the math standards and the science standards, is called out as it was in the climate change example [*see 'Excerpt,' page 5 sidebar*]. It is a mathematical modeling learning performance that actually coordinates across. As we were setting the framework, two people at the table were involved in Common Core Math.

We are in a project now, funded by the Gates Foundation, to do a year-long biology course and a year-long English course. We are doing deep crosswalks between Common Core ELA Science and Technology Standards, which are the reading and writing standards within ELA and the NGSS draft and the framework. The framework made clear that reading and writing of text is foundational to science and engineering investigation. Scientists spend more than half their lives interpreting text and generating text. Making your thinking visible and explicit through text, or representing your data and interpreting it opens up lovely learning processes.

That is a professional development need in general. To treat reading and writing as is called for in the Common Core is not what most science teachers already do. There is a great synergy to explore and figure out in order to make the life of a teacher a little simpler, especially as nonfiction finds its way into the ELA standards. • Philip Bell

Assessment Intentions

• For many years people said, "If only we had testing just like reading and math we'd get respect." I don't wish for that because I don't

really want to have them decide. In reading and math, the measurement becomes the goal rather than providing information about how you're doing. There is no good intention that can't be undone. What is the intention of folks who are working on assessment, and how will that get expressed so that it won't turn into something that will be the enemy of what we are trying to do instead of being helpful? • **Participant**

- Martin Storksdieck was talking about how the Board on Science Education has a project to do a consensus study to pull together a vision for assessment in relation to the framework vision, and he was hopeful that it could come out as a pre-publication by late spring or summer. It is still in process, so he can't talk about what the committee is deliberating. He did say they are spending a lot of time looking at classroom assessment in the more formative category as a leading focus, and not high-stakes accountability assessment.

  Unless ESEA gets reauthorized in a way that either includes science or dampens down accountability in ELA and math, we are in the situation we are in. My take is that the classroom level assessment is going to be crucial and is a good place to focus the field right now. However, my state science person is whispering in my head that to graduate high school in Washington State you have to pass the end-of-course biology test, so of course school systems are all organizing to get kids through biology. I was in a conversation with one public high school and they said, "Well, maybe we don't teach physics anymore." You can't not teach physics, but there are pressures on them other than the NCLB pressure.

  At some level we have to figure out assessment across the disciplinary areas in ways that make sense, ways that would allow Washington State to say, "We are not going to do that biology end-of-course test because we want an aligned assessment that is a better prophecy for science understanding by the end of high school." At some point that has to happen, but I do want to underscore the fact that this should be a slow process. It a ten- to fifteen-year vision. We need to find our way into the work. We need as a field, to sequence it a bit so that we are doing it in the right order. • **Philip Bell**

Focusing on a Child's Interdisciplinary Learning Experience

- Elementary school is an interesting point in a child's development. The sidewalk tends to diverge, and it is not a single fork in the sidewalk that a child takes after fifth grade. There are five or six forks in the sidewalk. We go from a single teacher who has the child's attention in all disciplines and has an opportunity, which some take and some can't, to interface all the disciplines in the experience of a child through the course of a day.

  For the rest of their educational careers students then get split into independent side-

Group discussion

walks. What we have found, and where our MSP is hopefully moving, is the reconvergence of the math, the science, the engineering opportunities, the ELA opportunities, all coming back into single experiences in multiple environments. The overlap is really in the way the practices are brought forth. When do NSTA, NCTM, and ACTE sit down at a table together and ask how these practices can occur in all of our environments together so that a child in a math classroom goes through an authentic science practices lab as they are exploring math concepts?

Someone mentioned a fourth grader trying to look at waves. We can't get eighth grade educators to teach waves as it is right now, but can we provide the experiential opportunity for a child to at least be exposed at a fourth grade level to the fact that waves exist around us? My belief is yes. The problem is, it can't happen in a single moment and unfortunately, the way education is happening currently, all of the standards, all of the experiences, and all of those crosscutting practices are happening in a single moment and then we move on.

How do we then empower the IHEs, the school district-level, and all involved, to say everybody has to do this together? The math teacher can employ science practices as they take a child through a mathematical investigation in the practices as a scientist might go through it. The same thing can happen in an English classroom. They can write about a math or a science experience.

So the documents are great if you read between the lines of the framework and really absorb the mindset that was behind it. It really broadens it out. The problem is that we as an education system are so bound by the idea that whatever is printed on the paper is what we have to do, and we have to do it at some given moment.

I was charged by the State of Georgia to look at their new engineering standards at the high school level. During a meeting, as we went through the standards the state department said, "We need to present the standards in this linear path because the teachers want the standards to correlate directly to the order in which they need to teach the material." Teachers in the room were also saying that was what their colleagues need.

The same thing happens in the sciences. If you look at some of the states' science standards and at the scope and sequence of science instruction, the standards map directly to the order in which the scope and sequence has to take place. What is being done, as these documents are being written, to get people to look between the words and actually focus on the experience? • **Participant**

Interdisciplinary Curriculum Design

- One thing I hear underscored in your statement are different dimensions of curriculum design. Until we have curriculum that delivers a more interdisciplinary image of science and engineering in relation to math and language, broader fields of teachers won't be able to come into that space easily. We could have a side-conversation about that. There is good work and research on the idea that if you take a really high-quality curriculum and let teachers adapt it and localize it, it is a very powerful move. If you let them invent curriculum from ground zero and define pieces and assemble it, that is not such a good move. You need to wait until the curriculum is in place because you can't think about certain choices until you have resources. • **Philip Bell**

- There was an interesting appendix that was in the *Next Generation Science Standards* released in January that was about school design. It's their practice to take those resources down after the review period is over because they're in revision, so if you can't

find this let me know and I'll email it to you. It was basically saying here are three models for how high school might be organized to accomplish the learning goals in the framework and the standards.

One was the classic biology-chemistry-physics arrangement, but interdisciplinary within because the learning goals fit together in a more interdisciplinary way. Second, you could arrange by the three disciplinary areas—all the life science standards, all the physical science standards, all the earth and space. The third model was the most interdisciplinary. Looking at the full set, they were basically trying to guess what were the relevant progressions through this set of learning goals. The reaction of the review panel I was on was, how would the system reorganize itself to be that interdisciplinary?

It's a good conversation to have, and over the next five years I am hoping that a lot of different test beds show up to realize different approaches so that we can understand how a deep coordination between science, math, and engineering can happen.

The framework laid out engineering applications of science and technology at a much higher level than had been present in the past. Probably in this "STEM moment" we can infer why we thought that was a useful move. The states thought having a fourth area on engineering applications of science and technology was not so helpful, so they lobbied to embed them within the other three areas. In the January release there were these asterisked learning performances. Those are the ones that are more design-centered and engineering-related. The thought is, you're showing how biotechnology fits within life sciences, you're making that kind of instructional move. I'm hoping really powerful curricula help do that work so that students are brought into design-related endeavors from kindergarten through twelfth grade, parallel to science investigations, hopefully in meaningfully intertwined ways. • **Philip Bell**

Implications for Teacher PD

- You were talking about teacher development, which we have conventionally done by grade level. I think you were suggesting a different way to do it. Could you talk more about that? • **Participant**

- STEM disciplinary experts often think their most powerful role is helping people understand disciplinary content knowledge, and that certainly is a huge, powerful role for them. What is new is actually around the practices. The eight practices are multifaceted. The modeling practice involves all sorts of intellectual work that scientists do. I'm hoping the scientific community steps up to help people understand the practices in that way. The footnote there is that scientists don't know that what they do is special because they are living in the fishbowl of doing the work, so

Retooling Schools of Education

- A lot of time, energy, and good value is spent on the retooling of the standards to make learning progress. When will we spend that same amount of effort to retool the training system? We can retool the standards, we can do our darnedest to offer PD to teachers in the field at the moment, but when will we really make an effort to retool the system that is putting people in the schools to do this kind of work? They are still coming out of schools of education with the alarming expectation that teaching is like what it was in the Seventies and Eighties, not the teaching that the standards and society are now trying to make happen. • **Participant**

Philip Bell

Mining Past NSF-Funded Curriculum

- Regarding curriculum issues, is there any effort under way at Achieve or elsewhere to analyze past NSF-funded curriculum to see about alignment? • Participant

- That is a really useful project idea. We need deep analysis of existing materials in which we've already invested heavily to see what would be involved in bringing them into alignment with the learning goals and standards and the framework. I've talked to folks at BSCS about whether we could do that or just need to restart. As of a year ago, they were thinking we mostly have to restart. EDC and TERC probably have positions on this as well in thinking this through. • Philip Bell

Group discussion

you have to help them understand that the practices are not just obvious to everyone. I have a colleague in geochemistry, and we were reading about expertise in the geosciences. He said, "I don't know what is involved or what it's about, that's just what we do." It's an expert blind spot issue.

That is a grade band issue also. The standards laid out what modeling looks like in the K-2 band versus the high school band, and they developed a kind of progression, which is a little bit more conjectural because we don't have a research base on those progressions. So another role is to coordinate across, using scientists or other tools to help teachers understand that reasoning for evidence looks like this in second grade, reasoning for evidence looks like this in eleventh grade. Lets figure out how to bring them into this work around different ideas.

One of the deep inefficiencies around teaching that I see show up over and over again is the teachers' belief that they need to restart the teaching of a topic, just because they can't or don't want to trust what came before. Often this is for very good reasons. I work with a lot of secondary teachers, and students don't show up having learned what they needed to about light before you try to take them into that part of the physics curriculum. At the same time, I think if we organized ourselves to do professional development across grade bands so that in the third-to-fifth grade band we really get them to an understanding of light, by the time they reach high school and pick up those ideas again we are able to actually build on their prior knowledge. That is the kind of thing we should be thinking about because ideas unfold across K-12 in a new way. The math standards are the same way, so it's a general issue that calls for professional development to think differently. • Philip Bell

Inquiry vs. Practices

- I was reflecting on the science inquiry standards that we had in the mid-1990s. What is it you think is so innovative about the practices over the inquiry standards? Is it that it now looks at it in more detail because of the progression? A lot of these practices—modeling, reasoning, reflection—were in the inquiry standards. • Participant

- Even though inquiry was defined through the standards in the Nineties, inquiry still came to mean many different things. It became forms of engaging kids in hands-on things that really weren't about deep learning or engagement in the knowledge work of the discipline. We tried not to use the word "inquiry" in the framework all. Our move was to say, if this is the one document that is going to travel, let's not lead with the word "inquiry" because it has too many meanings. Let's lead with the word "practices," made up of these eight core practices, as a refinement of "inquiry."

One of the things people do when they look at these is say, "Oh, this is the new scientific

method and you have to go through, one through eight," and our reaction is, "No, no, no!" A very specific professional development goal is to be clear that different sequences of overlapping practices make up investigations that are meaningful, and there is no one set order. In our design work we talk about this as a "cascade of practices." You're trying to help the field understand that, and I don't think we got there that often in the Nineties.

We also have new literature about learning through the practices that we didn't have in the Nineties, some of the richer underlying substance of explanation or argumentation. Actually, we just have a richer research base to know how to support that, what the scaffolds are, and then what the learning outcomes are. We were moving in the right direction in the Nineties and we are building on that history pretty directly, but we are also updating it based on the research piece.
• **Philip Bell**

Missing: The "How-To" Process

- Teachers want to know how to teach this. Going through this whole progression from framework to standards and eventually implementation, I think that what I wanted to come out of all this was some process for how to do this, the whole country coming together to talk about process. It's not about standards, it's about a process to make this really work. We've had some little statements over the past day or so about the American education system as if it's a joke. Well, it's our constitution. Every state has that responsibility to educate. I wasn't looking for a set of standards. I think every state should do that, that is your responsibility, but this was an opportunity to come up with a process and a document that could guide what we do.

We've jumped too far, too fast. I would have loved to have seen someone say we have taken this too lightly. It was a rush to get to a document. You're trying to turn around a ship as if you want to turn around a Volkswagon. You cannot do that. I would have loved to see someone go into a corner and ask, if this is the vision we want, how do we get there? We are very good at writing what we want but not how we're going to do it. And I am very fearful that the document will fail because we are misusing it. This is my rant.

We're talking about assessment, we're talking about instruction. We don't have teachers to teach it! What difference does it make if we get a perfect standard, a perfect test, if we don't have teachers to teach it? Go into a corner, look at what's needed, come out and give it to us, and then let the state do what the state has to do to make it a reality.
• **Participant**

- That was an incredibly important rant. To be honest, I wasn't sure I wanted to go to the table to be part of the standards setting process. Because of what has happened around NCLB, I didn't necessarily think it was

Building the Plane as We Fly It

- I appreciate the thoughtfulness I've heard here. I fear that my state, New York, will not move slowly because there is an urgency here tied to the economics of the state science and technology education. If you go to the state's website there's a motto that they use: "Building the plane as we fly it." They actually have a video of a plane being built while passengers are on it and they say, "We know we're doing that, it's okay." That's my fear—I think it's coming fast and furious. • **Participant**

Group discussion

a productive move. Ultimately I did because it was an opportunity to update a vision for the field more broadly, to say this is what we are questing after, this is what every student has a right to. The system should organize itself to make sure that students have the degree of freedom in their lives to make all sorts of life decisions that many students can't make right now. At the moment, standards are the one policy mechanism that has the chance of reorganizing the entire system and opening up conversation.

There are a lot of threats, like going too quickly with assessment, and all sorts of things to worry about. There is one group in the process conversation with whom we could all productively engage. The state science supervisors are part of a project called Building Capacity in State Science Education. There is the opportunity to have that be a thoughtful, long-term process, and not just a mad rush to solve the next thing that's hitting the system. In our state I know that it has opened up all sorts of collaborations across the state that are really generative and seem to have a long-term impact, that aren't just about doing the standards.

At the same time, I will say that equalizing opportunities to learn is such an ongoing challenge. This is a resource-intensive set of learning goals, and we haven't figured out how to equalize access in that way. That is one of the biggest issues that we need to keep working on. • Philip Bell

Opportunity for Collaboration and Coherence

- For the first time I see a real opportunity for various school districts to come together in a consortium to develop it, instead of each school district trying to figure out how to play this out, especially in areas where there is a lot of mobility between school districts. It would be a convergence of resources. I would then play that up to states, which could work together regionally. Or it could involve states that are similar to each other, even though they are not contiguous. Again, they could pool resources to create actual models of what this looks like. As a former teacher I know that teachers want to do, to act, but don't know what it looks like.

  There is an opportunity for consortiums of universities and colleges, especially those that produce a lot of teachers, to come together to create models of what this looks like. It's not just about the teacher in the third grade, it's about all the people who educate the teacher in the third grade. We haven't ever had that moment where we could come together because my standards were different from your standards, or I teach fifth grade and you teach third grade. All of this is an opportunity for people to come together to create it instead of everybody doing their own thing. • Participant

- The opportunity for increased coherence is profound and new and is ours to squander if we don't figure out how to organize ourselves. It is surprising to me how many teacher education programs are not oriented to the vision. Those of us motivated towards coherence just need to figure out how to get those wheels moving. We do have projects across districts now that are doing just what you are suggesting, saying, "We want to bring teachers together over these three practices over this next year. Let's do it together." That wasn't happening before.
  • Philip Bell