Notes on articles:

Middle School Integrated Science – Get Over It

CSTA http://www.classroomscience.org/middle-school-integrated-science

Here is the domain specific model:

6th Grade	7th Grade	8th Grade
Weather and Climate	Cells and Organisms	Physics-Heat
Natural Resources/Geology	Ecosystems	Physics
Earth History	Evolution	Chemistry
Astronomy	Engineering	Engineering
Human Impacts		
Engineering		

Summary of Domain Specific Model adopted by the California State Board of Education.

Wait a minute, what's up with all of the content being shoved into 6th grade? Well domain specific means that Earth and Space Sciences is in 6th grade, and

there is lots of content in Earth and Space Science. **(The above table is not an accurate portrayal of amount of content. See NGSS: ESS has 15 PEs, LS has 21 PEs, and PS has 19 PEs)**

Much of it is developmentally inappropriate for 6th graders who will be challenged with the huge time and special scales encountered in Earth History and Astronomy. **(Close examination of Math CCSS show that 6th graders will be learning science concepts concurrent with math concepts which is also the case in all earlier grades 1st through 5th. Check out Math CCSS requirements for earlier grades.)**

There is also the background in physics needed to understand how things move in space that requires some of the physics in 8th grade. **(This will allow for a spiralling exposure of the concept of gravity and its influence on planet and satellite motion/orbit. Also, the focus on the topic of gravity is different in the ESS PE vs. the PS PE. Take a look at the action verb and noun combination in the two different PEs)**

Also, tracking how matter like carbon and nitrogen flow cycle through ecosystems at 7th grade requires an understanding of chemical reactions that students won't get until 8th grade. **(These are focusing on different aspects of matter which combined is a lot of information to cover: 1) Tracking movement of matter through an ecosystem is a big picture conceptual understanding which will include a brief overview of the concepts of atoms and molecules, but will focus bulk of attention on cycles of matter; 2) Physical science discipline will drill down on the concept of chemistry, including subatomic particles, Intro to Periodic Table, molecule & compound formation, interactions and reactions between substances and identification of physical and chemical properties and changes. Trying to cover both of the above concepts at the same time could dilute students understanding and more importantly remove an important concept spiralling opportunity by clumping the two together. Research supports that re-exposure of concepts annually has a greater impact on learning as opposed to infrequent spiralling exposures to concepts)**

Here is the integrated model:

6th Grade	7th grade	8th Grade
Energy – Heat	Chemistry	Physics
Cells and Organisms	Ecosystems	Evolution
Weather and Climate	Natural Resources/Geology	Astronomy
Human Impacts	Earth History	Human Impacts
Engineering	Human Impacts	Engineering
	Engineering	
Systems, Patterns,	Energy and Matter	Stability and Change
Structure and Function	Cause and Effect	Scale

Summary of Preferred Integrated Middle Grades Learning Progression Adopted by the California State Board of Education

Why did the Science Expert Panel favor the integrated model?

There were several reasons:
Integration shows that real world science is integrated, meaning that real world problems need ideas from different disciplines to be solved.**(NGSS is already integrated. The National Research Council (NRC) designed it to be so by making it three dimensional. The Science**

and Engineering Practices and Crosscutting Concepts were created with the express purpose of generating a natural organic integration. See Ch. 9 of the NRC Framework, link)

Integration helps make the crosscutting concepts more central (the second box at the bottom).

Integration helps create stronger storylines (see my article in *CCS* last month).

Much content in Earth and Life requires physical science as background, such as forces for astronomy, chemistry for ecosystems, etc…, **(I absolutely agree and these provide natural avenues to integrate by speaking about the chemistry and physics behind LS & ESS phenomena as they are encountered during a discipline specific delivery. This should allow for more frequent discussions of how the fields truly are integrated. Also, you have greater student learning about this fact when there is a high exposure frequency to the integration of the domains rather than a coarse grained chunking as proposed in the current "Integrated Model").**

and as already discussed, 6th graders are typically not developmentally ready for astronomical scale and geologic time. **(Close examination of Math CCSS show that 6th graders will be learning science concepts concurrent with math concepts which is also the case in all earlier grades 1st through 5th. Check out Math CCSS requirements for earlier grades.)**

There is also the issue of needing chemistry to understand ecosystems and physics to understand astronomy. **(Some would argue that students engage with and better retain "just in time learning" of these concepts. As mentioned earlier, they will witness the true integration of the domains when you have short but frequent discussions about the Chemistry and Physics behind LS & ESS phenomena).**

There is a complete rationale for the CA integrated science model at: http://www.cde.ca.gov/pd/ca/sc/ngssstandards.asp.

http://www.classroomscience.org/middle-school-madness

Middle School Madness: The Integrated or Discipline Specific Choice

Posted: Tuesday, July 8th, 2014

by Robert Sherriff

Arguments for Integrated approach in article by Robert Sherriff

1. The SEP had trouble making a clear conceptual flow using the discipline specific model, which is one reason for their preference for the integrated model.

The integrated model includes logical links to the Common Core State Standards, and takes into account the progression of concepts from kindergarten through 8th grade with special attention to the progression between 5th and 6th grade so that the transition from 5th to 6th would be conceptually sound. Specifically, the SEP spent much time on the integrated model to ensure that it was developmentally appropriate for Common Core mathematics. With the alternative model, the SEP did not find it provided the developmentally appropriate Common Core math progressions, and has some conflicts in the conceptual progressions between 5th and 6th grade and therefore the alternative model was not considered to be in the best educational interest of middle school students.

(Close examination of Math CCSS show that 6th graders will be learning science concepts concurrent with math concepts which is also the case in all earlier grades 1st through 5th. Check out Math CCSS requirements for earlier grades.)

Overall the SEP found that the alternative model links and conceptual flow are at times a bit of a stretch. There are many examples of this, to demonstrate one example is:

Integrated model: Concepts involving gravity and astronomy are both in 8th grade.

Alternate model: Concepts on gravity are in 8th, Astronomy concepts are in 6th grade.

(This will allow for a spiralling exposure of the concept of gravity and its influence on planet and satellite motion/orbit. 6th graders will focus on *developing a conceptual model* of how gravity holds solar systems and galaxies together and influences the motion of planets and stars which generate predictable clustering (orbital) "patterns". 8th

grade focuses on students *constructing and presenting an argument* for the claim that gravity is attractive and dependant on masses of objects. While both PEs discuss gravity each is focusing on a different Science and Engineering Practice (SEP) for the topic.

The re-exposure of students to the concept of gravity in both 6th and 8th grade will help reinforce the phenomenon).

"Is there research that shows that the integrated model of teaching is beneficial to students?" Part of the research includes CA Scope, Sequence & Coordination: Students in integrated biology scored the same or better than students in traditional biology on the Golden State Exam. Scott, G (2000). Also, countries with top science scores require participation in integrated science instruction through Lower Secondary, and seven of ten countries continue that instruction through Grade 10. Achieve (2010).

(Achieve designed NGSS to address and incorporate integration of content and practices in the National Framework and in the new Science standards by developing the three dimensions (CCCs, SEPs, and DCIs). They explicitly say that this is how they integrate the domains as their research team discovered in countries with top science scores.

California SEP added another layer of integration which I believe takes away from teaching students how the domains truly are integrated and reduces the frequency of exposure to this fact. The SEP's Integrated Model juxtapositions large chunks of different domains that don't always integrate well naturally. This will quite possibly have the opposite effect the SEP desired when several teachers delivery is more of an abrupt shift between physical science, life science, earth & space science, and engineering and technology topics. We need to focus more on integration of cross cutting concepts, science and engineering practices and Engineering & Technology in our teaching and less on chopping topics up so that one integration approach fits all.)

Finally to develop an expert knowledge base the research in learning theory indicates that what is needed are connections developed through an interdisciplinary real-world approach over an isolated discipline specific approach in K-8. (NRC 2012).

(**Again this is the rationale for having the 3 dimensions in NGSS as Achieve decided to do to insure connections "through an interdisciplinary real-world approach." Achieve also wanted to avoid the isolated silo approach so they intentionally designed the standards to be three dimensional. Especially the CCCs and Science and Engineering Practices help break out of an isolated silo approach and bring about a real world problem based directive.**

Unfortunately, this discussion has moved us away from the original intent of NGSS, which is integrate SEPs & CCCs into the DCIs along with the Engineering, Technology and Application of Science (ETS) component. We are elevating and giving the LS, ESS & PS domains or DCIs too much clout and slipping back into our old way of doing science which focuses mostly on content knowledge. We need to put more focus on learning to integrate as the NRC intended and speaks about in the Summary introduction:

> "To support students' meaningful learning in science and engineering, all three dimensions need to be integrated into standards, curriculum, instruction, and assessment. Engineering and technology are featured alongside the natural sciences (physical sciences, life sciences, and earth and space sciences) for two critical reasons: (1) to reflect the importance of understanding the human-built world and (2) to recognize the value of better integrating the teaching and learning of science, engineering, and technology. (NRC Framework Summary, p 2, 3rd paragraph)"

Did the composition of the SEP represent a broad spectrum of the scientific community?

The SEP was made up of 27 Science Experts who are representative of the SRT (State Review Team of 85 members of the science community). The SEP consisted of K-12 Teachers, COE Science Leaders, IHE Faculty, Business, Industry, and Informal Science Centers. Input from the larger science community was considered. Firms such as Boeing and organizations such as NASA had representatives on the SEP.

The SEP had Noted Scientist Advisors including:

Dr. Bruce Alberts, biochemist, past president Nat'l Academy of Sciences

Dr. Helen Quinn, particle physicist, who helped develop the unified theory

Dr. Art Sussman, biochemist, noted author of science curriculum

(Teachers will naturally integrate as long as they are intentional about implementing the Engineering, Technology and Application of Science (ETS) PEs along with the CCCs, SEPs & DCIs. The beauty of NGSS is that each PE in every domain is comprised of components of the 3 dimensions, so a focus on directing our students to successfully perform as outlined in the NGSS as a whole will better help facilitate their success to knowing how to address and solve a variety of science questions and engineering problems.)

"Did the SEP consider a variety of models including the discipline specific models before they voted on the integrated middle school model?"

The SEP worked on various models including the discipline specific model, but in the end, SEP voted unanimously that an integrated approach was the most beneficial model for scientific literacy in middle school. **(I agree that an integrated approach is most beneficial, but rather than legislating only one integration model allow teachers to bundle PE's and integrate in a way that fits their school/district culture best. Let's allow NGSS to integrate naturally as it was designed to do so primarily with its 3 dimensions)**

For example, NGSS integrated model recognizes that it is meaningless to teach plate tectonics in earth science without incorporating the physics of density, as is teaching evolution in biology without the evidence found in earth science.

(I agree; however, allow teachers to naturally integrate and bundle PE's as makes sense for their school/district's culture. The overlapping of physical science, life science & Earth & space sciences can be more readily caught by students when it naturally overlaps while teaching with a discipline specific approach. Most teachers can naturally weave these disciplines together to give an integrated picture that is more organic without the abrupt topic shifts and deep drilling to the point of forgetting why we left a discussion on say for instance physics and now we're diving head long into a deep learning endeavour of natural selection. The integration fabric is too coarse and students will have a more difficult time making real felt connections between the large topic shifts. Plus revisiting a concept each year will help build a tighter spiralling weave in our teaching that will reinforce concepts when they're more frequently revisited, even briefly, each year. The integration fabric is more easily felt, understood and caught by students

when it is not so coarsely integrated with large chunks of each discipline shoved together as proposed by the Science Expert Panel's preferred model. With this approach students are more likely to lose sight of why they left the last domain and are now onto something different).

What were the guiding principles for making decisions for which middle school progression should be recommended?

In considering the path to MS Arrangement the SEP took into account that:

- NGSS middle school in grade span arrangement 6-8
- NGSS as both DCI and as a Topic arrangement
- CA instructional materials adoption dictates grade level placement
- Must align with Common Core ELA and Math
- Must build within and across grade levels to tell a coherent conceptual flow of ideas
- Be balanced in complexity and quantity at each grade level (In the integrated model there are fewer standards in 6^{th} than 7^{th} and even more in 8^{th}. In the alternative model there are more standards in 7^{th} than 8^{th}.)

(This is true but one must consider the time to bring about proficiency in the PS vs. LS disciplines. Physical Science has 3 PEs calling to plan or conduct investigations and one PE asking to undertake a design project, whereas LS only has one PE calling for an investigation and no design projects. Plus there is a greater demand for integration of math in the PS discipline.)

- Integrate the new engineering concepts appropriately

"Was teacher expertise and passion a consideration in deciding on the integrated middle school model?"

The short answer is yes; and it was brought up by myself and others. However, in response, SEP members concluded that students' scientific literacy was paramount, but that some staff development should be offered by the state to help those who felt they needed more on a particular sub-discipline of science. I'd like to add that this was initially a concern of mine, but through dialogue, I eventually realized that teachers must be open-minded about, and be passionate for, science as a whole. In the end, the science advisers and the SEP group felt that to solve the more

complex problems of today, we need experts that take a multidisciplinary approach. This is another line of reasoning to support integrated science through 8th grade with specialization after that.

(I agree that concern for students future needs should dictate the decision made. I personally feel that both models would work IF integration of 3 dimensions is our 1st priority and the ETS discipline is not forgotten. However, I feel you will have a simpler, cleaner and more efficient transition to full NGSS if you choose the discipline specific model because of teacher's existing training and passion for specific disciplines. Also, with the Discipline Specific model you still have opportunities for "organic" integration as natural opportunities develop when teaching concepts in LS & ESS that require Physics and Chemistry concepts be discussed. Plus Physical Science can always use LS & ESS examples as context to illustrate specific concepts)

What was the SEP rationale for the decision for the integrated model?

I believe Dr. Art Sussman expressed the rationale well: "The SEP very seriously considered the option of having discipline focused concepts for grades 6, 7, and 8. It quickly became very clear that there had to be foundational physical science concepts in grade 6 to be able to do the NGSS middle school life and earth science concepts. However some of the physical science concepts were clearly too advanced for grade 6th (required math concepts and skills that are beyond grade 6 level in addition to being too complex for grade 6). That combination of needing some physical science in grade 6 but not being able to do all physical science in grade 6 made the discipline specific approach impossible." This logic as well as many other examples and fact-based arguments provided the rational.

(I disagree with Dr. Sussman's statement. As stated earlier, the foundational science concepts needed provide a natural, non-forced, organic mode for integration, although at a cursory/conceptual level, but yet to a degree that students understand is necessary to bring about full understanding of the primary topic. An example of this is when one covers structure of cells and levels of organization these are both great places to discuss molecules and atoms as building blocks to cell structure. It would also be good to provide a scale reference for size of atoms/molecules to that of cells. By doing so you are integrating CCCs: structure & function, and scale, proportion & quantity. Also, in 8th grade when you delve deep into atoms and molecules you can cycle back on cells made

of atoms topic. These natural integration and spiralling exposure opportunities will be lost with the model as proposed by the Science Expert Panel.)

This leads to a new question that John Galisky of Lompoc High School (also a SEP participant) raised. "Won't the cumulation of all these mini-prerequisite lessons take away from time needed to cover the main PEs for that specific discipline you're teaching?"

(They could if a teacher goes too far down the rabbit trail, but as with all the new NGSS curriculum, each teacher will be making adjustments and changes to dial in their pacing so to insure adequate time spent for student success. You're in the same boat with the Integrated model because it's new to all of us.)

What criteria did the SEP use to arrange the particular PE's (performance expectations) (standards) for grades six, seven, and eight.

- Performance expectations (PEs) were placed at each grade level so that they support content articulation across grade levels (from 5th through 8th grade) and provide the opportunity for content integration within each grade level.
- Performance expectations were aligned with the Common Core State Standards in English Language Arts and Mathematics so that science learning would not be dependent upon math skills not yet acquired.

(See earlier comments on this. CCSS for Math and ELA is not a problem with the Discipline Specific model. Students will learn Math concurrently, as is the case for all grades K-5)

- The final arrangement of performance expectations reflected a balance both in content complexity and number at each grade level with human impact and engineering performance expectations appropriately integrated.

A couple of final points are that Achieve (the group that wrote the NGSS) liked the California middle school integrated model so much that they included it in their appendix for the NGSS, and we are the only state to have that honor as of this date.

(The Integrated model was included because of the significant efforts by California's SEP in arranging PE's into three courses with prerequisite PEs laid out in successive order for concept development and also for CCSS Math grade level requirements. This model is very efficient in covering the PEs with little or no revisitation, and provides a gradual increase in complexity or concepts, but I believe, and I think research supports, that removal of re-exposure opportunities, in what might be viewed "on the surface" as a less efficient approach, will decrease overall mastery of concepts especially at the critical maturation stage for students in grades 6, 7 & 8.)

For your use I have created a comparison chart of the integrated versus the discipline specific models for an unbiased comparison, I made this chart so that each grade level would fit on one page so some of each P.E. standard had to be left off. The charts are available for download here.

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