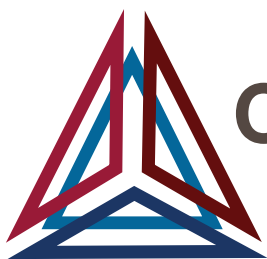




IMPLEMENTING THE NEXT GENERATION SCIENCE STANDARDS
Hallmarks of a Fully Realized School System



C-STEMEC

Chicago STEM
Education Consortium

science • technology • engineering • math

March 2013, Revised October 2013

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Algebra acts as a gatekeeper for high school graduation and post-secondary success. Students who pass Algebra 1 by the end of ninth grade are more likely to take advanced mathematics courses, graduate from high school, and succeed in college. Yet persistent inequities in access to rigorous algebra due to issues of placement, preparation, and quality of instruction have kept the gate closed for a large proportion of students, particularly minority and low-income students. In response, “Algebra for All” policies have been implemented whereby all students are required to take Algebra 1 by a designated grade level—typically eighth or ninth grade. This paper provides recommendations to: (1) better prepare students to succeed before taking Algebra 1; (2) enhance learning opportunities for underprepared learners *during* Algebra 1; and (3) enhance teaching capacity to support all learners, particularly those who are underprepared to succeed in Algebra 1.



The adoption of the Common Core State Standards for mathematics and accompanying PARCC assessments will have profound consequences for schools and districts. Since standards interact with other aspects of the educational system—curricula, assessments, human capital, district, and school organization—isolating collateral impacts is difficult. This decision has five important consequences for schools and districts:

- More (and different) learning for students.
- More (and different) learning for teachers.
- More (and different) learning for administrators.
- Different (and more challenging) assessments.
- The system is in a greater state of flux than in the recent past

Based on these consequences, this brief presents six major recommendations for schools and districts preparing to implement the new Common Core State Standards for mathematics.



This paper articulates a set of recommendations that will support K-12 Science, Technology, Engineering and Mathematics (STEM) education implementation and advancement in Illinois. The focus is on state-level strategies, and includes recommendations about how to discuss and define STEM education, what to do about the Common Core State Standards for Mathematics and the Next Generation Science Standards, and how STEM education efforts could be governed and organized throughout the state.

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EXECUTIVE SUMMARY

The publication of the Framework for K-12 Science Education and the subsequent release of the Next Generation Science Standards are a signal that it is time for science to assume the level of prominence in our education system that it has in the real world. An appreciation of the value of science, grounded in a firm understanding of science as a framework for making sense of the natural world, allows an individual to be a productive member of society, able to make wise decisions and understand the consequences of their actions. In essence, providing all students with a solid science education is a civil rights issue and, to compromise an individual's science education is to deny that person full participation as a member of society.

These new standards are a call to action for all stakeholders to make the changes necessary in our education system to bring forth a fully realized school system embodying the vision set forth in the Framework for K-12 Science Education. Implementing the NGSS: Hallmarks of a Fully Realized School System outlines this vision for K-12 science education and describes the shifts embedded within the NGSS. The hallmarks or elements identified in the report, and listed below, focus on three clusters of action: curriculum and instruction, assessment, and system capacity. They present a picture of districts, schools, classrooms and partnerships that are aligned with the NGSS vision, and they will assist administrators and teachers as they begin their conversation about how to implement these “fewer, clearer and higher” standards. Hallmarks for partnerships are also addressed because successful implementation of the NGSS will require working with many different people and organizations. All of these hallmarks require those who support and provide science education to take a step back and self-assess at all levels, to envision what students can become, to demand that science be valued, and to do their part in making the NGSS a reality.

Teachers (Classrooms):

- Are knowledgeable about and fluent with the Science and Engineering Practices, the Crosscutting Concepts and the relevant Disciplinary Core Ideas for the subject they are teaching.
- Have the best possible curriculum and instructional materials aligned to the NGSS, and are able to implement the curriculum and utilize the instructional materials with fidelity.
- Utilize formative, curriculum--embedded assessments based on real world applications of the Science and Engineering Practices, Crosscutting Concepts and Disciplinary Core Ideas.

EXECUTIVE SUMMARY

Principals (Schools):

- Promote the implementation of a curriculum that is fully aligned with the NGSS and make available to their teachers instructional materials that allow for sustained implementation of the curriculum over time.
- Recognize that science teachers require specific resources and facilities that must be sustained over time.
- Provide teachers with the time necessary to implement the NGSS consistently, every day, in every classroom, and ensure that every student has the time necessary for meeting these higher standards at every grade.
- Trust that faithful implementation of a curriculum and full use of the instructional materials that support that curriculum is the best way to prepare students to do well on assessments, including classroom-- and school--based formative and summative assessments and district--wide high--stakes assessments.
- Provide time and resources so that teachers can collaborate within and across grades around the implementation of the NGSS.

Superintendents (Districts):

- Place the highest possible priority on the teaching of science every day, in every classroom, at every grade, in every school, from the beginning of Kindergarten through the end of High School, and they communicate that message to all schools, administrators, and teachers.
- Understand that the successful implementation of the NGSS involves many stakeholders and requires that every person, policy or action be aligned towards the same goal.
- Recognize that implementation of the NGSS will require consistent effort sustained over time by all stakeholders.
- Recognize that science and the teaching of science have unique qualities and features that differ from other content areas.
- Provide an infrastructure and resources for supporting its schools and its educators.
- Understand that administrators require professional development to understand the nature of the NGSS and to develop strategies for supporting the implementation of the NGSS at their schools.
- Provide science teachers with frequent, sustained professional development on the NGSS, its implementation and on instructional materials to be used for its implementation.
- Provide teachers with the time needed to collaborate with other teachers, especially around looking at authentic student work.
- Provide the best possible curriculum and instructional materials aligned to the NGSS and includes support for teachers to learn how to effectively use these materials.

THE BEAUTY, WONDER AND UTILITY OF SCIENCE



Science is beautiful and wondrous, and helps people make sense of the natural world. It helps them be productive members of society by providing a framework within which to evaluate information about the natural world, make wise decisions, and understand the consequences of their actions. Never has this been more true than now, with the American Association for the Advancement of Science (AAAS) choosing as its 2013 conference theme, *The Beauty and Benefits of Science*, citing the “unreasonable effectiveness of the scientific enterprise in creating economic growth, solving societal problems, and satisfying the essential human drive to understand the world in which we live.”

It is time for science to assume the level of prominence in our K–12 educational systems that it has in the real world. To not do so is to deprive our students of the opportunity to engage in this way of learning and knowing about the natural world. Science is not a mere collection of facts; as Poincaré stated, “an accumulation of facts is no more science than a pile of bricks is a house.” Science is not an esoteric approach to obscure phenomena happening in an isolated laboratory. It is far more than a subject in school. Science is both a body of knowledge and a process for understanding how the natural world works. We must provide all students with a rigorous, comprehensive education or else we may be dooming them to continue to rely on muddled thinking and haphazard, ineffective approaches to solving problems about the natural world.

Science learning should not be reserved for only a select group of students nor should it be a subject to “get to” once reading and math have been mastered. Postponing science for some students or making it of secondary importance is to treat those not receiving a comprehensive education inequitably. All students must begin receiving a rigorous, continuous, uncompromising science education beginning in Kindergarten and continuing throughout High School. This has become a matter of equity in the 21st Century.

A VISION FOR ALL STUDENTS

Students receiving a rigorous science education based on the Framework for K-12 Science Education and the Next Generation Science Standards (NGSS), Kindergarten through High School will:

Possess a scientific habit of mind.

They actively and persistently explore science, employing the practices used by scientists. They are skillful inquirers, ask testable questions, find systematic ways to address those questions and then learn from both successes and mistakes—revising their worldview when necessary.

Develop an accurate framework of key, unifying science concepts.

They have the ability to build onto the conceptual framework with the understanding that the ‘facts’ of science will continue to build and change across their lifetime. They know how to access the latest science findings using scientific and literacy skills.

Critically analyze scientific claims.

They are able to use evidence-based reasoning to access traditionally accepted and new ideas. They are able to assess the validity of claims to both understand what is valid versus unsubstantiated, and to solve problems.

Be effective communicators about science.

They are skillful in asking questions, illuminating different views, highlighting agreement, disagreement and unknowns, and individually and collaboratively expressing understanding of science to various audiences.

Understand the integral role of science in society.

They understand that science is used to address real world issues, and they have an appreciation of the interconnectedness of science with their everyday lives.





WORD WIZARDS

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CHURCHILL DOWNING

The Next Generation Science Standards build upon earlier efforts in science education reform that began in the 1990s with the publication of the AAAS Benchmarks for Science Literacy and the National Science Education Standards. We have learned much about science as well as how students learn science in the years since these landmark publications were released, and the NGSS represent an evolutionary step in the direction of providing all students with the science education they deserve. The major shifts in these standards as compared to the earlier efforts are:

Integrated nature of scientific practices, content and unifying ideas:

The NGSS are based on the realization that scientific practices and concepts cannot be extricated from one another for science education to be effective, and that there are unifying ideas that pervade all scientific disciplines that help students develop a conceptual framework in science. This premise was laid out in the Framework for K–12 Science Education as the Three Dimensions of science teaching: 1) Science and Engineering Practices, 2) Crosscutting Concepts, and 3) Disciplinary Core Ideas (DCIs). The authors invoked the image of the three dimensions as being intertwined strands of a rope. Although this intertwined nature of practices and content was mentioned in earlier efforts, it is now at the forefront of the NGSS.

Depth, quality and progression:

The Framework and the NGSS make explicit that for science education to be effective, we should focus on fewer ideas in greater depth, rather than trying to cover a large number of topics superficially. The Framework clearly articulates how the depth of student understanding of Disciplinary Core Ideas (as well as the Science and Engineering Practices and the Crosscutting Concepts) should progress across the grade bands. The NGSS articulate these learning progressions. The Framework makes clear that not all scientific topics will be taught in K–12. Rather, learning the core ideas by engaging in the practices and integrating the crosscutting concepts, will equip students with the knowledge and tools to continue to learn about science after graduation.



New or newly-emphasized Disciplinary Core Ideas (DCI):

The integration of engineering represents a major shift in the standards. It allows students to understand that scientific understanding is the precursor to the application of this knowledge to design needs or challenges. Earth Science, which in high school (and into college) is often considered a less rigorous topic, can no longer be considered as such as Earth and Space Science figure prominently in the NGSS. Evolution is one of the four Disciplinary Core Ideas in the Life Sciences. In districts and states where Evolution has not been clearly identified as a learning standard, this is a major shift in focus. Waves and their applications for technologies for information transfer is a completely new area of focus in the Framework and NGSS, being one of the top-level DCIs in the Physical Science.

Scientific Inquiry defined:

In previous science reform documents, such as the National Science Education Standards, the importance of teaching scientific inquiry in addition to science concepts was emphasized. However, the term “inquiry” was subsequently interpreted in a multitude of ways over time. The authors of the framework have specified what is meant by scientific inquiry by articulating the Scientific (and Engineering) Practices in Dimension 1. They state, “as in all inquiry-based approaches to science teaching, our expectation is that students will themselves engage in the practices and not merely learn about them secondhand” (p.30).

Real world connections:

The Framework makes clear that science must be taught in a way that allows students to see the relevance to their real lives. Connections to the natural world around them, as well as the engineered environment, should be emphasized. This will engage students and help them understand the personal and societal value of science.

Connections to other disciplines:

The NGSS explicitly incorporate engineering as the application of science to solve real world problems. Rather than teaching engineering as a discipline separate from science, it is integrated in a natural manner. Additionally, explicit connections to mathematics and literacy are made throughout the Framework and are embedded in the NGSS. For example the Crosscutting Concept of Proportion, Scale and Quantity is easily linked to Mathematical Practices in the Common Core State Standards—Mathematics. Further, many of the practices in science, such as constructing “arguments from evidence” have parallels in literacy and within CCSS— English Language Arts.

Students and equity:

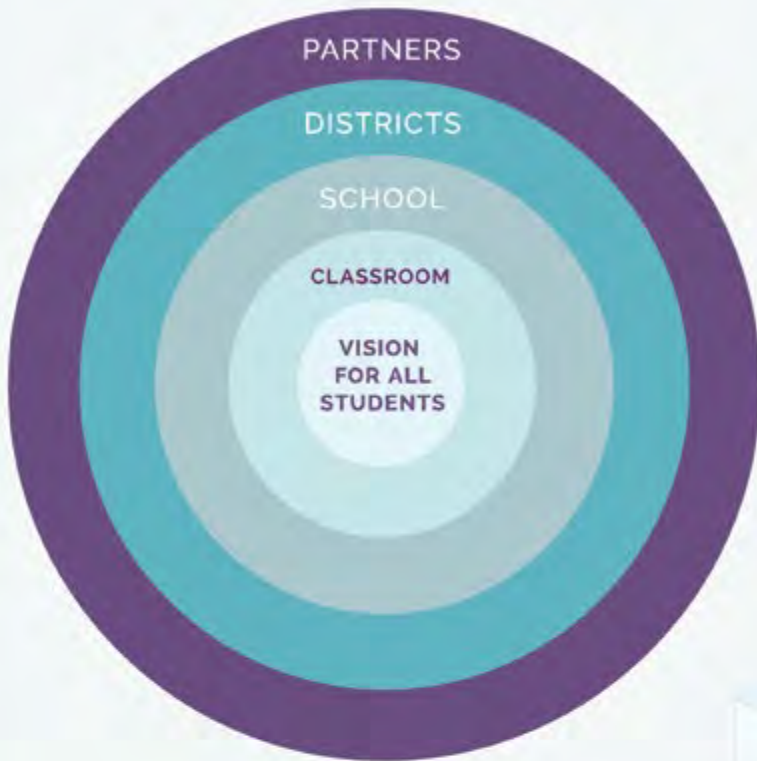
The NGSS clearly lay out a set of standards for all students. As seen in their definition of a College and Career Ready student, all students, whether they go to college to become a science major, or they enter vocation or trade school, are expected to reach the same level of proficiency and competency in science. The Framework clearly articulates a need for science literacy for becoming a productive member of society in general; the standards are placed in the context of overall “human achievement.”

Science standards as performance descriptors:

The NGSS comprise a series of performance expectations, by grade (K–5) or grade-band (Middle School and High School). That is, they represent the “assessable component” of science education. Rather than simply describing what students should know by the end of each grade or grade band, the NGSS make clear how a student should be able to demonstrate their understanding of all three dimensions of the Framework. The shape of the NGSS will require more performance--focused assessments than have been emphasized in the past.



Hallmarks of a Fully-Realized Science Education System



HALLMARKS OF A FULLY REALIZED SCIENCE EDUCATION SYSTEM

The Next Generation Science Standards, based on the Framework for K–12 Science Education, are a call to action. The Framework (Chapter 10) outlines all of the controls in an education system that must be aligned for the system to fully implement the NGSS as intended by the authors. Such a system is complex and has many controls, from the teacher through the federal government, including families and communities, private businesses, and non-formal educators. When these controls all work in concert, with everyone and every institution sharing the same vision, then the hopes and dreams for all students, as outlined in the Framework can be achieved: “By the end of 12th grade, all students:

- Should have some appreciation of the beauty and wonder of science;
- Possess sufficient knowledge of science and engineering to engage in public discussions on related issues;
- Are careful consumers of scientific and technological information related to their everyday lives;
- Are able to continue to learn about science outside school; and
- Have the skills to enter careers of their choice, including (but not limited to) careers in science, engineering, and technology.”

Everyone involved in an educational system—as defined broadly in the Framework—shares the responsibility of working towards these endpoints for all students. Some actions are large, and require more time and resources for change and alignment; others are small, and can begin today. Here we describe the hallmarks or elements of an educational system that is fully aligned with the NGSS, focusing on three clusters of actions: curriculum and instruction, assessment, and system capacity. We present this picture to serve as a vision for districts, schools, and classrooms as administrators and teachers begin their conversations about how to implement these “fewer, clearer and higher” standards. Following these hallmarks, we outline some suggestions for closing the gap between the current reality and the vision for K–12 science education.



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HALLMARKS OF A SCIENCE CLASSROOM

A classroom that provides a high quality science education aligned with the NGSS has a teacher who is knowledgeable about and fluent with the Science and Engineering Practices, the Crosscutting Concepts and the relevant Disciplinary Core Ideas for the subject they are teaching.

The quest for excellence requires teachers to engage in sustained learning as part of their lifelong enterprise as professional educators. In a fully-realized system, teachers are afforded and avail themselves of opportunities to build their professional capacity to fully implement the NGSS with fidelity. Teachers self-assess their continuing needs for professional growth, including enhanced science content knowledge, greater facility with inquiry-based teaching strategies, and more experience engaging in real-world scientific endeavors. The professional development options available to teachers are coherent, frequent (research shows that 50--80 hours per year is ideal), and sustained over time, ideally three to five years (the time it takes to implement an innovation.)

The professional development offered to and sought out by teachers enables them to acquire new knowledge, apply it to practice, and reflect on the results with colleagues. It includes job-embedded collaborative teacher learning strategies, such as instructional coaching, analysis of authentic student work, peer observation of practices, professional learning communities or cohorts, professional development connected to curriculum and instructional materials, and activities that take into account school structures and routines.

HALLMARKS OF A SCIENCE CLASSROOM



A classroom that provides a high quality science education has the best possible curriculum and instructional materials aligned to the NGSS, and teachers who are able to implement the curriculum and utilize the instructional materials with fidelity.

Excellent science instruction aligned to the NGSS is based on a curriculum that embraces all three dimensions of the Framework: Science and Engineering Practices, Crosscutting Concepts and Disciplinary Core Ideas. The instructional materials used to implement the curriculum are carefully constructed to allow students to demonstrate their understanding of the three dimensions through a variety of means, over a period of time. The curriculum has a coherent story line connected to the real world that permits students to develop a conceptual framework within which to organize their understanding of science.

The teacher has an implicit understanding of and familiarity with the curriculum, and can seamlessly “tell the story” woven throughout. They are thoroughly familiar with the instructional materials, having attended high quality professional development on the effective implementation of these materials, and they use them fully to support the curriculum. The teacher uses practices true to the NGSS, and uses diverse instructional strategies based on best practices in science teaching (as described in *Taking Science to School*), and draws upon literacy and mathematical practices outlined in the Common Core State Standards to help reinforce the interconnected nature of science with other content areas.

The teacher understands that textbook--based instruction, in which the primary instructional strategy is reading about, rather than engaging in science, does not align with the NGSS. Because the NGSS represent an evolutionary shift, rather than a revolutionary one (that is the NGSS build upon rather than usurp the previous efforts in science education reform), certain instructional materials already exist that are well aligned with the Framework and with the type of science learning specific in the second draft of the NGSS. These high quality, reform- and research-based, NSF-funded programs include, but are not limited to, FOSS, STC, IQWST, SEPUP, BSCS, ChemCom, and Active Physics.

A classroom that provides a high quality science education aligned with the NGSS has teachers utilizing formative, curriculum-embedded assessments based on real world applications of the Science and Engineering Practices, Crosscutting Concepts and Disciplinary Core Ideas.

These teachers understand that the most effective way to assess their students is to continually gauge their understanding through formative assessments embedded in the curriculum and based on daily classroom instruction, using everyday instructional materials. These formative assessments include performance-based tasks in which students demonstrate understanding of the concepts and ideas while engaged in the practices. They know that meaningful summative assessments aligned to the NGSS should include performance-based and project-based activities, and will require time and commitment on the part of both the teacher and the student.

The teacher makes authentic assessment practices a priority, and knows that science is not about getting the “right answers,” but is instead about developing an understanding of the natural world by using evidence to support claims and engaging in critique of scientific ideas. The teacher knows that using multiple methods for assessing students is important to allow all students, regardless of English language or learning ability, to demonstrate their conceptual understanding. They also understand the value of collaborating with other teachers around looking at student work. Such collaboration helps teachers to understand student pre- or mis- conceptions, and to make decisions on how to adapt instruction accordingly.





A school that provides a high quality science education promotes the implementation of a curriculum that is fully aligned with the NGSS and makes available to its teachers instructional materials that allow for sustained implementation of the curriculum over time.

Schools help put the right curriculum and instructional materials into the hands of their teachers. Curricula and instructional materials are chosen by a team of experts, including teachers with the correct expertise, who are thoroughly familiar with the Framework and the NGSS. Most teachers are not trained to be curriculum writers—they are trained to teach—and even fewer teachers have the time to create a curriculum and assemble a set of instruction materials *de novo*. Fortunately, as previously noted, instructional materials already exist that are well aligned with the Framework and with the type of science learning specified in the second draft of the NGSS. These programs, all high quality, reform- and research-based, NSF-funded include FOSS, STC, IQWST, SEPUP, BSCS, ChemCom, and Active Physics, among others.

Schools ensure that the curriculum they choose to implement embodies the conceptual shifts called for in the NGSS. The curriculum thoughtfully integrates the content with the practices and crosscutting concepts. It presents scientific concepts in such a way that ideas build upon one another, tell a story, connect to the real world and engage students' emotions. Schools ensure the chosen curriculum allows student learning to progress as explicitly outlined in the NGSS for all three dimensions (practices, concepts and ideas). Schools empower their teachers to carry out the conceptual shifts of the NGSS by ensuring they have the right teaching materials and have support in learning how to implement them so as to promote students' deep understanding.

A young man with dark hair, wearing a white shirt, is looking intently at a river. The river has greenish water and several large pieces of driftwood. The background shows a lush green forest. The image is partially obscured by a purple header bar at the top and a white text area on the right.

HALLMARKS OF A SCHOOL

A school that provides a high quality science education aligned with the NGSS recognizes that science teachers require specific resources and facilities that must be sustained over time.

Schools understand that to teach and to learn about science requires resources, including instructional materials and their continued replenishment over time. They understand that inquiry-based science requires equipment to conduct laboratory and field investigations, and that supplies are consumed in the process of conducting those investigations. They understand that for students to reach the higher goals established in the NGSS, their students must have a continual and sufficient supply of materials to fully engage in the practices of science.

Schools also understand that hands-on science inquiry, as outlined in the Framework and NGSS require facilities geared towards the types of investigations and experiments that scientists conduct. These facilities include laboratories with equipment appropriate to the grade levels utilizing the laboratory (note that elementary and middle schools may require this type of facility, not just high schools). Schools provide space to accommodate the types of performance- and project-based learning required by the NGSS. Projects take time, and need a place to reside as students continue to work on them systematically over a sustained period of time. Schools maintain these facilities and spaces, upgrading them as needs emerge.

Schools provide teachers and students with access to technologies as needed to address the NGSS. Schools recognize that technology includes, but goes beyond computers and the Internet. As stated in the Framework, technology includes all types of human made systems and processes, and “Technologies result when engineers apply their understanding of the natural world and of human behavior to design ways to satisfy human needs and wants” (Framework, p 12). Schools understand what technologies teachers need to foster student learning and behavior, enhancing instruction rather than competing with it.

A school that provides a high quality science education aligned with the NGSS provides teachers with the time necessary to implement the NGSS consistently, every day, in every classroom, and it ensures that every student has the time necessary for meeting these higher standards at every grade.

Schools recognize that time must be allotted to science instruction to allow students to engage in the practices of science while constructing their understanding of the concepts and ideas. This understanding builds and progresses in a coherent and sustained manner over 13 years, and beyond, with students developing an ever more sophisticated understanding over time. Schools insist that science be taught every day, in every classroom, with ample time for students to think deeply about their learning. They understand that carrying out science-related activities will not result in learning unless students have the time to internalize, explain and justify their understanding, and engage in discourse about science with their peers.

Schools realize that science teaching is inherently related to, rather than a competitor with student learning in literacy and mathematics, and that the NGSS not only draw specific connections to the CCSS-ELA and Math, but that they are philosophically aligned. Schools guard against incursions into the time allotted for science instruction by explicitly stressing the right of all students to receive a high quality science education.



HALLMARKS OF A SCHOOL



A school that provides a high quality science education aligned with the NGSS trusts that faithful implementation of a curriculum and full use of the instructional materials that support that curriculum is the best way to prepare students to do well on assessments, including classroom- and school-based formative and summative assessments and district-wide high stakes assessments.

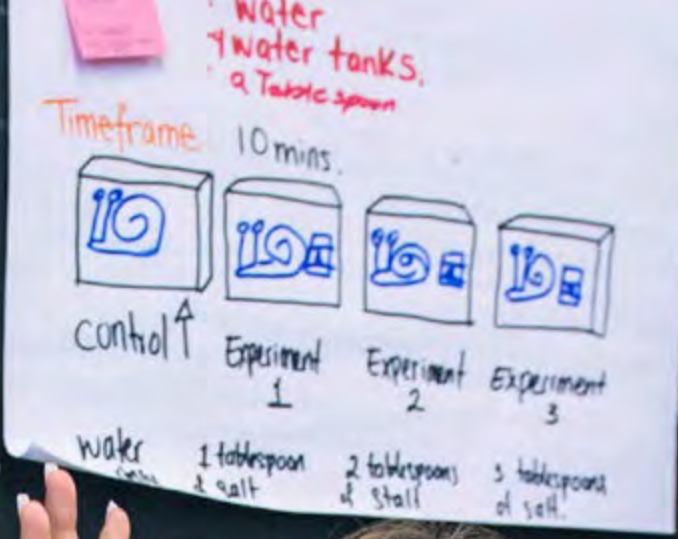
Schools understand that formative assessments are tools that inform instruction, not compete with it, and that these assessments offer insights on student learning over time, not just lesson by lesson. They know that authentic assessments, embedded in the curriculum and instructional materials, that can be implemented seamlessly in everyday instruction are the most effective way for teachers to gauge the understanding of their own students and to modify instruction based on their particular needs. Schools understand that assessments aligned to the NGSS will require performance- and project-based activities, and that off-the-shelf multiple choice tests cannot provide insight into student thinking and understanding of the NGSS—they can only gauge whether students have provided the correct answer, as defined by the test-writers. Assessments must ask students to engage in the practices while demonstrating conceptual understanding of the big ideas in science; that is, they must ask students to be scientists.

A school that provides a high quality science education aligned with the NGSS provides time and resources so that teachers can collaborate within and across grades around the implementation of the NGSS.

Schools understand that collaboration time is essential for systemic, sustained, positive change to occur. As made clear in the Framework and the NGSS, science is a social endeavor; thus, science teaching should also involve opportunities for teachers to share their successes and challenges with their colleagues regarding implementation of the NGSS. Schools understand that teachers will experience frustrations and false starts, and that a school climate that encourages teachers to share openly, without judgment or negative repercussions, will promote more reflection and a greater willingness to try something new.

Schools also understand that looking at authentic student work collaboratively helps teachers gain a greater and deeper understanding of student progress towards reaching the high standards set by the NGSS. It allows for discussion of student pre- and misconceptions, and dialogue around teaching strategies and modifications that will result in greater student understanding and performance. Schools understand the need for an infrastructure that promotes such collaboration: schedules are structured to allow for both grade-level and vertical collaboration time; professional development is designed to promote systematic examination of student work; and tools for collaborative sessions are provided. Such tools might include: protocols, rubrics, facilitation guides, and video or audio recording equipment to present student work that cannot be captured on paper.





Experimental Setup
Control: Surface without salt
Variables: Disturbance
Pressure, etc. pH, etc.



Homo habilis = 2.3-1.5 million years

Paranthropus boisei = 2.3 million years

Australopithecus africanus = 2.3 million years



HALLMARKS OF A DISTRICT

For districts with one or a very small number of schools, the “Hallmarks of a School” and “Hallmarks of a District” may be very similar and have significant overlap. For larger districts there may be a greater distinction between the two categories. Regardless of the size of the district, all of these hallmarks apply.

A district that provides a high quality science education aligned with the NGSS places the highest possible priority on the teaching of science every day, in every classroom, at every grade, in every school, from the beginning of Kindergarten through the end of High School, and they communicate that message to all schools, administrators and teachers.

Districts value science teaching and learning and insist that all of their students, regardless of grade, learning ability or English language ability, receive science instruction every day. They do not allow science to “take a back seat” to literacy or mathematics, or any other activity. They understand that in the 21st Century, access to a full-bodied science education is essential to be a productive member of society, and to deny that access is, in essence, a civil rights issue.

They communicate this message to all schools by setting minimum requirements for how many minutes per week should be devoted to science education aligned to the NGSS, beginning with at least 200 minutes per week in Kindergarten, and climbing to at least 300 minutes per week in Middle and High School. Further, districts require at least three years of High School science coursework aligned to the NGSS.



HALLMARKS OF A DISTRICT

A district that provides a high quality science education aligned with the NGSS understands that the successful implementation of the NGSS involves many stakeholders and requires that every person, policy or action be aligned towards the same goal.

Districts understand “A Vision for all Students” outlined here and in the Framework, and they develop a transparent, long-term strategy for implementing the NGSS that addresses all of the controls and components within and connected to its system. Districts welcome and seek feedback from all of the stakeholders, and use this feedback to inform their actions.

A district that provides a high quality science education aligned with the NGSS recognizes that implementation of the NGSS will require consistent effort sustained over time by all stakeholders.

Districts know that implementation of the NGSS is a complex process that will require slow, steady change. While there is an urgent need to ensure that all students receive a science education that will serve their intellectual needs, districts understand they have the time to ensure that this transition to the NGSS is done well. As Michael Fullan points out, during times of change, there is “the vital and paradoxical need for slow knowing”.

A district that provides a high quality science education aligned with the NGSS recognizes that science and the teaching of science have unique qualities and features that differ from other content areas.

Districts know that science is both a body of knowledge and a way of knowing about and understanding the natural world. They recognize that a worldview in science involves a habit of mind that relies on conducting investigations about the natural world using a variety of methods, using empirical evidence to develop explanations and revising ideas based on new evidence. They know that for students to learn science, they must be able to engage in the practices and use the tools that real world scientists use. Districts pay attention to and respect the uniqueness of science when developing strategies and implementation plans, taking action, and supporting their administrators and teachers.

At the same time, districts appreciate the interconnectedness of science with other content areas, and that the Science and Engineering Practices in the Framework reinforce the Standards for Mathematical Practice in the CCSS-M and the “capacities of a literate individual” for CCSS-ELA. They understand that science is complementary to, and not a competitor with these or any other content areas.

Districts with STEM programs recognize that STEM is an acronym for Science, Technology, Engineering and Mathematics that was developed years ago by the National Science Foundation (NSF) to be able to talk about the interrelatedness of these four fields of study in a shorthand way. Districts recognize that programs must align to the NGSS (and the CCSS-M) to be, in fact, truly considered STEM programs. Districts also recognize that STEM programs are academically-based, preparing students to develop a deep understanding of how Science (and Math) are used to inform Engineering and Technology and are not just work-force development programs.



HALLMARKS OF A DISTRICT

A district that provides a high quality science education aligned with the NGSS requires an infrastructure and resources for supporting its schools and its educators.

Districts understand that implementation of the NGSS requires resources including facilities, equipment, supplies, instructional materials, professional development for administrators and teachers, and access to experts in science and science education. Districts understand that they need to develop a sustainable infrastructure for providing this support for their schools, administrators and teachers. The supports are readily available and easy to access. Districts develop a plan for acquiring, maintaining, and managing the financial resources required for full implementation of the NGSS.

Districts understand that schools need access to appropriate technologies to implement the NGSS. Just like schools noted earlier, districts recognize that technology includes, but goes beyond computers and the Internet. The Framework defines technology as including all types of human made systems and processes, and states “Technologies result when engineers apply their understanding of the natural world and of human behavior to design ways to satisfy human needs and wants” (Framework, p 12). Districts listen to administrators and teachers to learn what technologies are needed to enhance instruction rather than compete with it.



A district that provides a high quality science education aligned with the NGSS understands that administrators require professional development to understand the nature of the NGSS and to develop strategies for supporting the implementation of the NGSS at their schools.

Districts understand that leadership at schools matters for science education. For administrators unfamiliar with inquiry-based science teaching and learning, the NGSS may represent a major shift in their understanding of high quality science instruction. Districts recognize that administrators need a greater understanding of the nature of science, and what a classroom looks like when students are engaging in the practices of science while constructing their understanding of scientific concepts and ideas. Districts help their administrators continue to develop a deeper appreciation of how students best learn science as described in *Taking Science to School* and in the NGSS.

Districts know that they must provide a consistent, coherent message about the value of science and science teaching so that school administrators, in turn, impart this same message to their teachers. Districts also reinforce with their school administrators that change takes time, and that teachers need to be encouraged to try new instructional approaches which may be difficult, and involve some failures before achieving success.



HALLMARKS OF A DISTRICT



A district that provides a high quality science education aligned with the NGSS provides science teachers with frequent, sustained professional development on the NGSS, its implementation, and on instructional materials to be used for its implementation.

Districts understand that teachers are the most important human resource in the educational system, and that teachers need professional development to support them when they use curricula with rigorous learning goals for students aligned to the NGSS. Districts understand that they must develop a plan for providing this support, and that it must be frequent throughout the year (research shows that 50–80 hours per year is ideal), and sustained over time, ideally three to five years (the time it takes to implement an innovation).

Full implementation of the NGSS at the classroom level may represent a major shift for some teachers, and may pose significant challenges and a sense of trepidation; districts acknowledge this and respond to emerging needs of teachers as implementation progresses. Districts also understand that professional development must be directly relevant to teachers, and must be aligned to the district's curriculum. Districts recognize what research shows, that without professional development to support the use of instructional materials, implementation remains at a superficial level. A district's professional development plan to support the implementation of the NGSS enables teachers to acquire new knowledge and apply it to practice utilizing the instructional materials actually being used in the classroom.

A district that provides a high quality science education aligned with the NGSS provides teachers with the time needed to collaborate with other teachers, especially around looking at authentic student work.

Districts understand, as do teachers, that collaboration with colleagues is essential for achieving success. Districts put structures in place to foster formal teacher collaboration both within and among schools, and they also foster a climate that promotes both formal and informal collaboration. Collaboration may include instructional coaching, peer observation of instructional practices, grade-level meetings focused on analysis of student work, vertical teaming to ensure the coherent progression of student learning across grades, professional learning communities and/or teacher cohorts.

The structures put in place by districts to foster these types of collaborations include schedules that allow time for teacher collaboration during the school day, financial supports for teachers to meet outside of the normal school hours, and a cadre of substitute teachers with science teaching expertise that allow teachers to observe colleagues' teaching practices.





HALLMARKS OF A DISTRICT

A district that provides a high quality science education aligned with the NGSS provides the best possible curriculum and instructional materials aligned to NGSS and includes support for teachers to learn how to effectively use these materials.

Districts develop a strategy and plan for selecting the best possible curriculum and instructional materials aligned with the NGSS. As noted earlier, districts assemble a team of experts who are thoroughly familiar with the Framework and the NGSS, including teachers with the correct expertise, to select the curriculum and instructional materials. Districts understand what makes science unique and that they cannot select science curriculum using the same strategies used to select CCSS-ELA or CCSS-Math curricula and instructional materials. Science teachers are engaged in curriculum selection, but the district recognizes that most teachers are not trained to be curriculum writers and even fewer teachers have the time to create a curriculum or assemble a set of instructional materials. Rather, all teachers need time to learn how to use carefully chosen new materials.

Fortunately, as noted earlier, instructional materials already exist that are well aligned with the Framework and with the science learning specified in the second draft of the NGSS. These programs, all high quality, reform- and research-based, and NSF-funded include FOSS, STC, IQWST, SEPUP, BSCS, ChemCom, and Active Physics, among others. Districts provide affirmation and support for teachers currently using these materials. They emphasize implementing these materials in even greater alignment with the NGSS, rather than make changes to instructional materials.

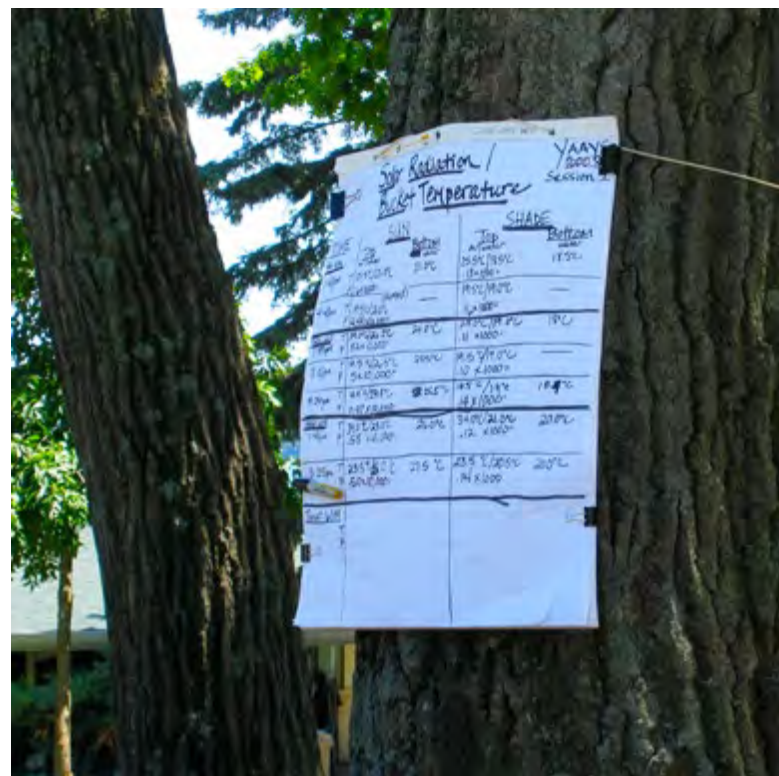
Districts, as noted earlier for schools, ensure that whatever curriculum they implement embodies the conceptual shifts called for in the NGSS. The curriculum thoughtfully integrates the content with the practices and crosscutting concepts. It presents scientific concepts in such a way that ideas build upon one another, tell a story, connect to the real world and engage students' emotions. They ensure the curriculum allows student learning to progress as explicitly outlined in the NGSS for all three dimensions (practices, concepts and ideas). Districts empower their schools to carry out the conceptual shifts of the NGSS by ensuring that their teachers have the right teaching materials and have support in learning how to implement them so as to promote students' deep understanding.

A district that provides a high quality science education aligned with the NGSS trusts that the best way to prepare students to do well on assessments is to support schools and teachers in faithfully implementing NGSS-aligned curriculum and instructional materials.

Districts trust that students do best on district-wide, high stakes assessments when they receive a rigorous science education aligned to the NGSS every day, in every classroom, in every school, in every grade. They understand that future high stakes tests, currently under consideration, will require performance- and project-based activities, and will not be “business as usual.” They realize that multiple-choice tests cannot provide insight into student thinking and understanding of the NGSS—they can only gauge whether students have provided the correct answer, as defined by the test writers. Future high stakes tests under consideration will require students to engage in the practices while demonstrating conceptual understanding of the big ideas in science; that is, they will ask students to be scientists.

Districts understand that the most effective way to assess students is through the use of classroom--based authentic assessments that can be implemented seamlessly in everyday instruction. Districts know that teachers are the ones best able to assess whether students have a deep understanding of the practices, concepts and ideas as outlined in the NGSS. They know that teachers do this by gauging their students’ understanding through formative assessments embedded in the curriculum and based on daily classroom instruction, using everyday instructional materials.

The district makes this classroom-based, authentic assessment a priority, and supports teachers in doing so, at all grade levels. Districts emphasize the importance of enacting the curriculum with fidelity so that students progress from year to year in their understanding of the Scientific and Engineering Practices, Crosscutting Concepts and Disciplinary Core Ideas. Districts recognize that assessments that incorporate the three strands of the NGSS are not simple to execute, and that teachers and school administrators require support to utilize them fully.





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HALLMARKS OF PARTNERSHIPS

As noted earlier, there are many controls in an educational system, many of which lie outside the direct control of the school system. Administrators and teachers know that successful implementation of the NGSS will rely on forming and maintaining external partnerships with key people and organizations. Here are the hallmarks of some of those key partnerships.

A partnership with colleges and universities that helps provide a high quality science education aligned with the NGSS is characterized by pre-service teacher preparation programs that are linked tightly with the actual expectations in the classroom with regard to curriculum and instruction.

In a true partnership, pre-service science programs are aligned tightly to the NGSS and the actual classroom reality of teachers in that district. Teachers develop a substantial familiarity with the NGSS and they are prepared to come into schools ready to educate their students to meet these more rigorous standards. Pre-service programs:

- Ensure that teacher candidates have the appropriate knowledge of Scientific and Engineering Practices, Crosscutting Concepts and Disciplinary Core Ideas as defined by the three dimension of the Framework
- Provide experience to their candidates using reform-based science curricula and instructional materials, such as those previously noted that align to the NGSS, and exposure to the tenets of how and why these programs were developed
- Provide the rationale for how to select instructional materials and professional goals for creating one's own science classroom that ensures instruction faithful to the NGSS

HALLMARKS OF PARTNERSHIPS



A partnership with colleges and universities that helps provide a high quality science education aligned with the NGSS is characterized by in-service professional development programs that are linked tightly with the actual experience of teachers in their classroom as they implement the NGSS.

In a fully-realized partnership, universities work in tandem with school systems to identify the professional development needs of their teachers, and the best ways to meet those needs. Universities have expertise that school systems may lack, while administrators and teachers have a better sense of the mechanism by which those needs can be met. A partnership involves dialog between a university and a school system, and will always involve developing professional development opportunities that are likely to have the most impact in the context of the particular school system. Professional development offered by universities may take several forms. It may involve instructional coaching, facilitating professional learning communities, promoting the development of teacher-leaders, facilitating vertical and grade level meetings, and helping to organize opportunities for peer observation. It may include coherent, frequent and sustained workshops or graduate courses for teachers that focus on NGSS implementation.

Universities also work with school and district administrators in helping them develop internal structures to support job-embedded learning and collaboration among teachers, and they help administrators understand the shifts that will be required at the school and district level to implement the NGSS fully.

A partnership with non-formal institutions that helps provide a high quality science education aligned with the NGSS provides both classroom and extra-curricular opportunities to facilitate teachers' implementation of the NGSS.

In a fully-realized partnership, non-formal institutions work closely with districts, schools and classrooms to fully understand their NGSS-aligned curriculum and are aware of the specific instructional materials being used in classrooms. The program offerings of non-formal institutions reinforce the curriculum, rather than compete with it, and teachers are able to implement these programs in a seamless way. As in classroom instruction, programs offered by non-formal partners require students to demonstrate an understanding of all three dimensions of the Framework.

A partnership with families and communities that helps provide a high quality science education aligned with the NGSS is characterized by parents and others developing an appreciation of the level of rigor of their students' science education, and helps parents develop an appreciation of the beauty, wonder and utility of science themselves.

A partnership with families and communities is based on the understanding that parents want the best for children, including a rigorous science education. Research shows that the overwhelming majority of society values science, and a fully-realized partnership allows school systems to validate that sentiment by acquainting parents and families with the nature of their children's science learning. Further, students help their parents and communities understand the personal and societal value of science by participating in family- or community based projects.



HALLMARKS OF PARTNERSHIPS

A partnership with businesses that helps provide a high quality science education aligned with the NGSS provides resources and opportunities for the study of science and engineering that are not available in a school setting alone.

In a fully-realized partnership, businesses have an appreciation for the NGSS and the higher standards for students. They make available to districts, schools and students opportunities to engage in the scientific enterprise in ways that are not available in a school setting, or that would be enhanced through the influx of additional resources. Businesses understand that these opportunities are more than simply work-force development programs; they are ways for all students to further develop a scientific habit of mind and see the relevance of science outside of school.

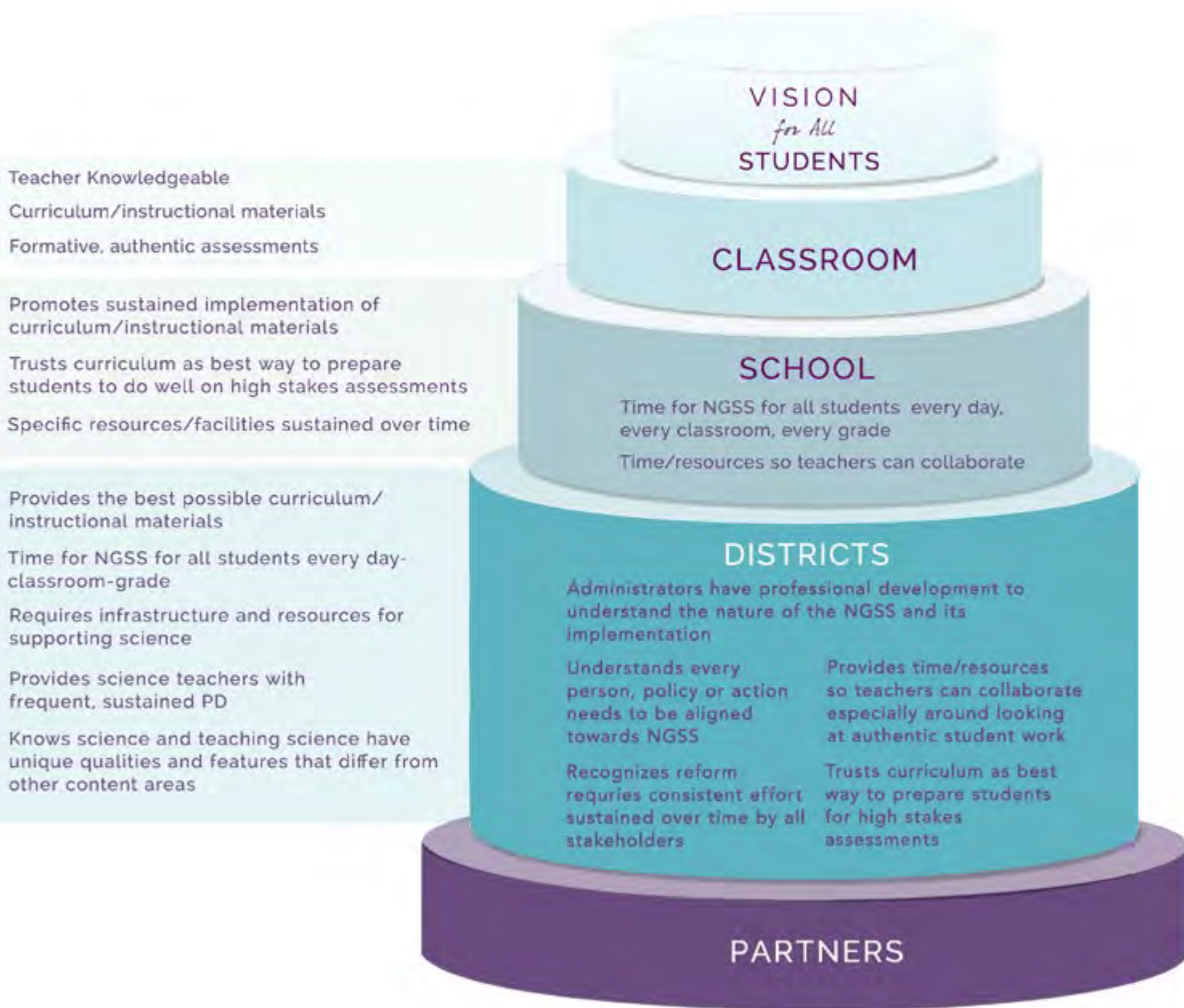
A partnership with the state board of education that helps provide a high quality science education aligned with the NGSS involves two-way communication that promotes state level policies, including assessment, that are in line with actual classroom instruction.

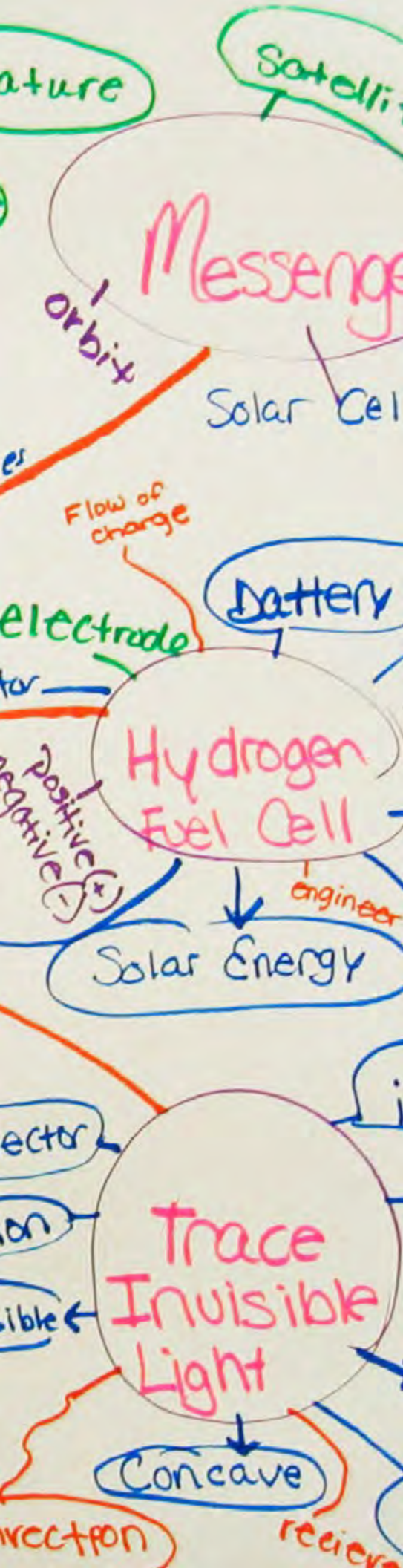
A fully-realized partnership between a school system and the state board of education works together to ensure that state-level assessments are closely aligned with the curriculum and classroom instruction. The partnership works together to ensure that assessments correlate with NGSS-recommended grade bands (Kindergarten to second grade, third to fifth grade, sixth to eighth grade, High School) to encourage teachers to teach appropriate science every year to build students' depth of understanding. Any assessments required by the state or district underscore the importance of students learning high quality science every year, all year.

Future standardized tests aligned to the NGSS must be rigorous assessments that incorporate the Scientific and Engineering practices, Crosscutting Concepts and Disciplinary Core Ideas and require more active demonstration of student understanding. The state helps school districts understand that these tests will not be “business as usual” multiple-choice tests that probe knowledge of isolated content. Rather, they are very likely to involve performance assessments. The state helps school districts understand the nature of these assessments and helps districts develop infrastructures for implementing them.



Hallmarks of a Fully-Realized Science Education System





FIRST STEPS/NEXT STEPS

Self-assess at all levels. The first step we recommend in this process of implementing the Next Generation Science Standards is to conduct a self-assessment at all levels—district, school, classroom and partnership. What is the current state of K–12 science teaching and learning at each level? Describing the current state of the different components in the system is an essential first step in the process as it provides the starting point for plans for change.

Envision what all students can become. Secondly, we recommend that all readers become familiar with the Vision for All Students outlined here and the Vision for K–12 Science Education in the Framework. As noted earlier, successful implementation of the NGSS requires that all students received a high quality science education, every day, in every classroom, every year, from Kindergarten through High School. Understanding the vision, and ultimately sharing it, is essential to the process. If this vision is not discussed among and shared by stakeholders at all levels in the system, then the system cannot be fully realized.

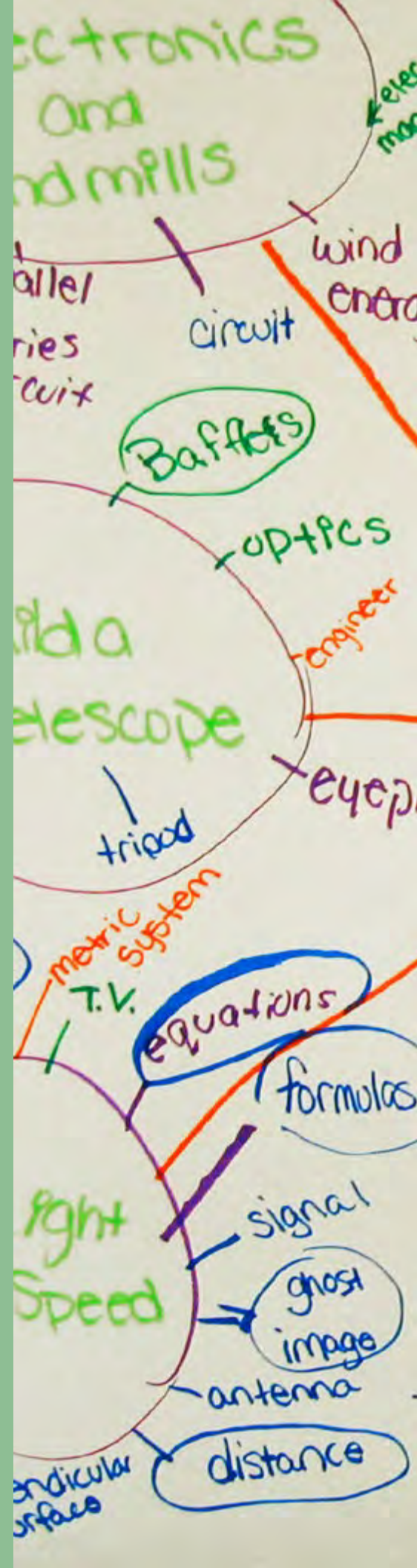
Value science as central to our world. In addition to sharing the vision, all components in the system must place the highest possible value on the teaching and learning of science. As noted earlier, science is not just a body of isolated facts that students learn about in school. Rather, science is a body of deep conceptual knowledge and a process for understanding how the natural world works. The Framework for K–12 Science Education clearly articulates the value of science to individuals and to society, especially in the 21st Century, and we recommend that all people in the system become familiar with the Framework and discuss it in depth with colleagues over time. If science is not as valued as reading and math, implementation of the NGSS is likely to face numerous obstacles, some of which may be insurmountable.

FIRST STEPS/NEXT STEPS

Connect, converse, collaborate. Connecting, conversing and collaborating with others—with colleagues, experts, and other stakeholders—is essential for moving an educational system and all of its components forward. We strongly recommend that all people in the system proactively seek out opportunities to learn as much as they can about how others are making plans for implementation of the NGSS. Teachers should connect with other teachers, principals with other administrators, and districts with other districts.

Strategically plan around the right drivers of improvement. It is imperative that all components in an educational system work together strategically to build classrooms, schools, districts and partners that have the hallmarks laid out here. The type of strategic planning that results in systemic change is slow going. Systems should take the time to think through plans carefully, and realize that the transition to the NGSS is intended to take place over several years. Systems will need plans at multiple time scales, e.g., 1 year, 2 years, 5 years, etc. These plans must include a vision for enactment of the NGSS built upon Fullan's right drivers: capacity building (rather than accountability), group quality (rather than individual quality), instruction (rather than technology) and systemic (rather than fragmented).

Each person can make a difference. Finally, while systemic change requires action at all levels, we should remind ourselves that we all have both responsibilities and opportunities to effect change, no matter where we are in the system. Small changes can and should occur while big changes are being considered, and as Margaret Mead said, "Never doubt that a small group of thoughtful, committed citizens can change the world; indeed, it's the only thing that ever has."



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SUMMARY OF HALLMARKS

Hallmarks of a Science Classroom

A classroom that provides a high quality science education aligned with the NGSS has:

- A teacher who is knowledgeable about and fluent with the Science and Engineering Practices, the Crosscutting Concepts and the relevant Disciplinary Core Ideas for the subject they are teaching.
- The best possible curriculum and instructional materials aligned to the NGSS, and teachers who are able to implement the curriculum and utilize the instructional materials with fidelity.
- Teachers utilizing formative, curriculum-embedded assessments based on real world applications of the Science and Engineering Practices, Crosscutting Concepts and Disciplinary Core Ideas.

Hallmarks of a School

A school that provides a high quality science education aligned with the NGSS:

- Promotes the implementation of a curriculum that is fully aligned with the NGSS and makes available to its teachers instructional materials that allow for sustained implementation of the curriculum over time. The best possible curriculum and instructional materials aligned to the NGSS, and teachers who are able to implement the curriculum and utilize the instructional materials with fidelity.
- Recognizes that science teachers require specific resources and facilities that must be sustained over time.
- Provides teachers with the time necessary to implement the NGSS consistently, every day, in every classroom, and it ensures that every student has the time necessary for meeting these higher standards at every grade.
- Trusts that faithful implementation of a curriculum and full use of the instructional materials that support that curriculum is the best way to prepare students to do well on assessments, including classroom- and school-based formative and summative assessments and district-wide high-stakes assessments.
- Provides time and resources so that teachers can collaborate within and across grades around the implementation of the NGSS.

SUMMARY OF HALLMARKS

Hallmarks of a District

A district that provides a high quality science education aligned with the NGSS:

- Places the highest possible priority on the teaching of science every day, in every classroom, at every grade, in every school, from the beginning of Kindergarten through the end of High School, and they communicate that message to all schools, administrators, and teachers. Recognizes that science teachers require specific resources and facilities that must be sustained over time.
- Understands that the successful implementation of the NGSS involves many stakeholders and requires that every person, policy or action be aligned towards the same goal.
- Recognizes that implementation of the NGSS will require consistent effort sustained over time by all stakeholders.
- Recognizes that science and the teaching of science have unique qualities and features that differ from other content areas.
- Requires an infrastructure and resources for supporting its schools and its educators.
- Understands that administrators require professional development to understand the nature of the NGSS and to develop strategies for supporting the implementation of the NGSS at their schools.
- Provides science teachers with frequent, sustained professional development on the NGSS, its implementation and on instructional materials to be used for its implementation.
- Provides teachers with the time needed to collaborate with other teachers, especially around looking at authentic student work.
- Provides the best possible curriculum and instructional materials aligned to the NGSS and includes support for teachers to learn how to effectively use these materials.
- Trusts that the best way to prepare students to do well on assessments is to support schools and teachers in faithfully implementing NGSS-aligned curriculum and instructional materials.

SUMMARY OF HALLMARKS

Hallmarks of Partnerships

A partnership with colleges and universities that helps provide a high quality science education aligned with the NGSS is characterized by:

- Pre-service teacher preparation programs that are linked tightly with the actual expectations in the classroom with regard to curriculum and instruction.
- In-service professional development programs that are linked tightly with the actual experience of teachers in their classroom as they implement the NGSS.

A partnership with non-formal institutions that helps provide a high quality science education aligned with the NGSS:

- Provides both classroom and extra-curricular opportunities to facilitate teachers' implementation of the NGSS.

A partnership with families and communities that helps provide a high quality science education aligned with the NGSS:

- Is characterized by parents and others developing an appreciation of the level of rigor of their students' science education, and helps parents develop an appreciation of the beauty, wonder and utility of science themselves.

A partnership with businesses that helps provide a high quality science education aligned with the NGSS:

- Provides resources and opportunities for the study of science and engineering that are not available in a school setting alone.

A partnership with the state board of education that helps provide a high quality science education aligned with the NGSS:

- Involves two-way communication that promotes state level policies, including assessment, that are in line with actual classroom instruction.



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BSCS: Biological Sciences Curriculum Study. A Science Education Curriculum Study. <http://www.bsos.org/>

STC: Science and Technology Concepts Program. Developed at the National Science Resources Center, Smithsonian Institution. http://www.nsrconline.org/curriculum_resources/stc_program.html



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