Junk Science Comes to School: The Next Generation Science Standards

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I. Introduction

In the years following the seminal report *A Nation at Risk* [1], published in 1983, American schools have been viewed as failing, a diagnosis that led to their subsequently being trapped in what is often described as a sausage grinder of standards-based education. Thirty years later, we have the Common Core State Standards (CCSS) for math and English language arts and the promises of "college-and-career readiness," as if these goals were somehow not met for American schoolchildren before the federal government supplanted traditional district-led education with standards and assessment-driven teaching. Not surprisingly, national replacement of science standards was not far behind.

The Next Generation Science Standards (NGSS)[2] were released in April of 2013 and, to date, have been adopted by 19 states and the District of Columbia. They were developed by a partnership of four entities including the National Research Council, the National Science Teachers Association, the American Association for the Advancement of Science, and the leader of this education-reform scheme, Achieve, Inc., the Washington, D.C.-based trade association that also took the lead in the CCSS.

The NGSS are not officially part of the CCSS which include English Language Arts (ELA) and mathematics standards; however, the NGSS were written to align with the CCSS as noted in the NGSS document. Note also that the ELA standards encourage teachers to inject science content into their "English" lessons – the official title of the ELA standards includes "Literacy in History/Social Studies, Science, and Technical Subjects." NGSS's alignment with the CCSS is found in the bottom section of each table labeled as "Common Core State Standards Connections" on each standard page.

Despite their fancy title, the NGSS are nothing more than a set of mediocre science standards that have not been vetted, were never piloted or otherwise tested, and reveal an overt political agenda embedded in K-12 education that parents, educators, and the general public should find troubling. The NGSS have distinctly different priorities from those of previously published K-12 science standards. Engineering, technology, environmental science, evolution, and climate change are given a much more prominent role in the NGSS compared to individual state standards around the nation.

The purpose of this paper is to outline the deficiencies of the NGSS and expose the politically charged junk science being channeled into American education by a mediocre set of national science standards.

II. The Design of the NGSS

The *Framework for K-12 Science Education* [3], upon which the NGSS are based, outlines three dimensions for science education: Practices, Crosscutting Concepts, and Disciplinary Core Ideas. This may seem somewhat confusing because traditional K-12 science education standards typically organize the content into two major categories: theory (called "core ideas" in NGSS) and practice (called "practices" in NGSS).

Definitions:

- **Practices** – What we would typically refer to as "skills"
- **Crosscutting Concepts** – Seven concepts identified that link ideas and practices across various science disciplines (for example, "cause and effect" might be discussed when studying earth and also when studying heredity)
- **Disciplinary Core Ideas** – General headings for the standards in the NGSS document, beneath which specific standards are located

The NGSS document claims to present a smaller set of core ideas but focus on deeper understanding and application of science knowledge. The "smaller set of core ideas" is certainly true, as a great deal of content is missing; however, the "deeper understanding" and application of science knowledge remains to be seen.

III. A Model of Mediocrity

In June 2013 the Thomas B. Fordham Institute published its *Final Evaluation of the Next Generation Science Standards*[4] document, which compared the NGSS with 55 other sets of science standards, including those from 50 states plus the District of Columbia, and four non-state standards including the Program for International Student Assessment (PISA), American College Testing (ACT), Trends in International Math and Science Study (TIMSS), and National Assessment of Educational Progress (NAEP). Fordham is self-described as "the nation's leader in advancing educational excellence for every child through quality research, analysis, and commentary." [5] Its evaluation exposes serious errors and inadequacies within the NGSS.

Each set of standards was given a grade of A, B, C, D, or F; a numeric score of 0 to 10; and a relative quality comparison with NGSS as "clearly inferior," "too close to call," or "clearly superior." In the words of the authors, they were "using substantially the same criteria as [they] previously applied to state science standards – criteria that focus primarily on the content, rigor, and clarity of K-12 expectations for this key subject." Based on this criteria, they ranked the NGSS at 26 out of a total of 56 standards, with a grade of 'C' and a numeric score of 5 out of 10. This makes the NGSS nothing more than mediocre in the world of state science standards.

The grade of 'C' by Fordham was based primarily on the issue of inadequate content. According to the Forward section of the Fordham review, authored by Chester Finn and Kathleen Porter-Magee:

> First, missing and "implicit" content. Pruning and prioritizing can be taken too far, and it does nobody any favors to pretend to omit content from one grade that later turns out to have been essential. Yet the NGSS sometimes does precisely that: it never explicitly requires some content in early grades that is then assumed in subsequent standards. [6]
>
> This problem is especially visible in the earth and space science section, where (in the review's words) 'so much implied content is inferred in a single statement that it is difficult to imagine just what one might expect to be taught.'[7]

The specific standards identified in the NGSS identify what "students who demonstrate understanding" can accomplish. Unfortunately, NGSS will not help students prepare for STEM (science, technology, engineering, and math) or any other careers; rather, it will be a severe hindrance to gaining even basic knowledge and understanding of critical science concepts. A bold claim? Not at all, if people actually read the NGSS and the comments from Fordham.

It is puzzling that some states with standards ranked as "superior" or "clearly superior" to the NGSS, in both grades and numeric scores, have cast aside those superior standards to endorse the NGSS. How can it be prudent to discard "clearly superior" standards in lieu of newer standards that have a lower ranking by Fordham and have no evidence from research as best practice in science education? Apparently, the dazzling appeal of shiny new standards trumps substance.

Equally perplexing is that some states with lower standards have chosen to adopt a new set of standards that is given only a grade of 'C,' rather than look to the states ranked in the top 10 for superior standards upon which to base their revisions. If states with a lower ranking in science standards wish to improve, it would be more judicious to consult those superior standards in correcting deficiencies.

IV. Problems with the Clarification Statements

NGSS supporters claim that the NGSS "are standards, not curriculum," and that the specifics of education will remain within the purview of local districts and the classroom teacher. But the structure of the NGSS belies that claim. Ninety-two percent (176 of the 191 specific standards) of the NGSS include a "clarification statement" which provides numerous specific examples of activities that students "could" and "should" engage in to "demonstrate understanding." The prevalence and content of the "clarification statement" is akin to requiring these and only these curricula and activities. Thus, the specifics of education will reside not in the local district but in the NGSS and the associated testing/assessments. Additionally, many clarification statements contain errors in facts, errors in concepts, and blatant political indoctrination.

<u>Example of clarification statement with errors in fact or concept:</u>

> "K-LS1-1. Use observations to describe patterns of what plants and animals (including humans) need to survive.
>
> [Clarification Statement**:** Examples of patterns could include that **animals need to take in food but plants do not;** the different kinds of food needed by different types of animals; the requirement of plants to have light; and that all living things need water.]" [8] [Bold added]

Plants not needing food will be news to the agriculture industry across the country that knows CO_2, with various nutrients and fertilizers, is "food" to plants, regardless of how some political groups regard CO_2.

<u>Example of clarification statement as substituting for curriculum:</u>

> "3-PS2-3. Ask questions to determine cause and effect relationships of electric or magnetic interactions between two objects not in contact with each other.
>
> [Clarification Statement: Examples of an electric force could include the force on hair from an electrically charged balloon and the electrical forces between a charged rod and pieces of paper; examples of magnetic force could include the force between two permanent magnets, the force between an electromagnet and

> steel paper clips, and the force exerted by one magnet versus the force exerted by two magnets. Examples of cause and effect relationships could include how the distance between objects affects strength of the force and how the orientation of magnets affects the direction of the magnetic force.]" [9]

With this much instructional detail (curriculum), a sharp 3rd-grader could probably teach the topic. Do competent classroom teachers require a clarification statement to teach to the standards? This same clarification also prevails in the Common Core State Standards through their use of both implementation documents and extensive teacher training. Why is this? A professional in the workplace, bringing appropriate knowledge, skills and experience as an educator, should not require prompts or suggestions as to how to develop students' understanding.

In reality, such prompts are necessary only for educators neither knowledgeable nor skilled in science. Dependence on what NGSS puts forth is then instilled and perpetuated, essentially the "world according to NGSS." This amounts to broad-spectrum indoctrination, with subsequent loss of local initiative and control.

Local education should serve the needs of the local community. If, for example, energy topics are relegated to political issues in the NGSS and are not the subject of an honest and accurate investigation of related pros and cons, then the residents of a state that produces energy through coal, oil, and gas are not well served by education within that state. Education should take into account the industries that fund that state because that is where the jobs will be for the graduates. NGSS supports the agenda of its authors, not the needs of the economy and citizens in individual states.

V. Limitations Imposed by Assessment Boundaries

Found on page 2 of the Executive Summary is the statement (bottom of the page, last sentence) that ". . . the NGSS do not dictate nor limit curriculum and instructional choices." [10] We have already seen how the clarification statements belie this claim. Another facet of the NGSS that operates to control what is taught in the classroom is what are called "Assessment Boundaries."

The assessment boundary is a statement of what is *not included on the test*. Sixty-six percent (127 of the 191 specific standards) of the NGSS include assessment boundaries, which were designed to inform testing companies for development of future assessments.

Realistically, in an educational system fraught with an overreliance on standardized testing to "grade" teachers as well as students, it only makes sense that teachers will to spend most of their time teaching to the test. Consequently, if a standard specifically states that a concept is not on the test, it will likely not be taught in the classroom, or if it is included in the lesson plan it will not be given priority, thus limiting the depth and breadth of what is taught for that standard. This poses a significant problem for true science education, because much content included in the assessment boundaries is crucial for understanding concepts that are foundational for future college-level life science courses.

Examples of limited content due to an assessment boundary:

Example #1

"HS-LS1-1. Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells.

[Assessment Boundary: Assessment does not include identification of **specific cell or tissue types, whole body systems**, specific protein structures and functions, or the biochemistry of protein synthesis.] [11] [Bold added]

In this assessment boundary we find that cell and tissue types and whole body systems will not be tested. Indeed, whole body systems are found nowhere in the high school life standards - a significant omission.

Example #2

"5-PS1-3. Make observations and measurements to identify materials based on their properties.

[Clarification Statement: Examples of materials to be identified could include baking soda and other powders, metals, minerals, and liquids. Examples of properties could include color, **hardness,** reflectivity, electrical conductivity, thermal conductivity, response to magnetic forces, and solubility; **density is not intended as an identifiable property.**]
[Assessment Boundary: Assessment does **not include density or distinguishing mass and weight**.]" [12] [Bold added]

Students in 5th grade are significantly affected by this assessment boundary. Ignoring the relationships between hardness and density, as well as the difference between mass and weight is akin to educational malfeasance for this age.

Assessment boundaries result in significant deficiencies in the NGSS. Typically, state standards (previous to NGSS) do *not* specify what is *not* on a test, so we question the reason for including this type of delineation in the NGSS. Although many teachers will teach to the test, we expect a few very dedicated science teachers will forge ahead with their higher-quality teaching and continue to do their best to ensure that students understand the science concepts that are critical to future collegiate science courses. Page 5 of the NGSS Release even states that the standards "do not prohibit teachers from going beyond the standards to ensure their students' needs are met." Unfortunately, the assessment boundaries ensure that in too many cases, the opposite will occur.

VI. The Glaring Omissions

The most obvious gaps in science content are found in the high school (grades 9-12) standards. The paucity of chemistry standards would not justify even a very basic one-semester chemistry course. Physics is all but completely absent, with an occasional rudimentary nod to a physics principle.

The life science standards are lacking a considerable amount of biology, including whole body systems, cell and tissue types, cellular feedback mechanisms, protein structure and function, cell division (mitosis and meiosis), bacteria and virus. Some omissions are a consequence of assessment boundaries, while others are obvious intentional exclusions.

Physical science fares no better. A standard physical science course, typically offered in the 9th grade year, would include Newton's first law, energy, thermodynamics, Ohm's law, simple electrical circuits, and lab safety – all missing from the NGSS. So much is missing, in fact, that there is not enough content for what used to be a one-year physical science class. Perhaps the reason for this omission is that this content is the prerequisite to the now nonexistent chemistry and physics course standards. It is no surprise that physical science concepts are so sparse - they are assumed to be unnecessary.

The most conspicuously absent concept is the ***scientific method.*** This omission alone should alarm anyone concerned with the quality of K-12 science education and the future of science in general. The scientific method is the logical and rational process through which we observe, describe, explain, test, and predict phenomena. While the scientific process is not always an identical linear step-by-step process in every study, and qualitative research admittedly relies on subjective observations, science still needs an established method by which to inquire, and then collect and analyze data. But this concept is nowhere to be found in the NGSS.

It is not unreasonable to predict that removing the scientific method will eventually eliminate intellectual scaffolding, producing a community of pseudoscientists who "feel" their way to answers through social and emotional enterprise, often relying on consensus rather than data and reliability of evidence. Without a consistent, systematic, and dependable method of science inquiry, the search for empirical evidence becomes nothing more than a game of subjective relativism, where the loudest player claims victory with their "answer" to the question.

Aside from the absence of scientific method, clear evidence of disregard for empirical evidence is found in the NGSS's overriding dependence on models. In fact, the word "model" is used an astounding 453 times throughout the entire K-12 NGSS, and 80 times in the standards themselves. At the middle school and high school levels, model-based standards comprise 27% of the total. Models are theoretical in nature; they are testable ideas based on observations and they can be helpful in science education for understanding conceptual relationships and phenomena. Models do not, however, constitute verifiable evidence; they cannot and should not be used as a substitute for empirical evidence within science enterprise or in science education standards.

There are indeed situations when using models is sensible. For example, when evaluating data on the theory of human-caused climate change, it would be ideal to compare an earth inhabited with humans and another identical earth that is uninhabited, used as an experimental control. Obviously we cannot make such a comparison, since another earth does not exist for scientific comparison, so all we have is a model that represents our "best guess" findings and predictions, rather than *real observable data.* The problem here is that students do not understand the inadequacies of a scientific model versus empirical evidence that can be verified and replicated. Clearly there is no way to completely avoid the use of models because we do not live in an ideal world; however, the unnecessary overreliance on models in lieu of observable and verifiable data exposes students to potential errors and incorrect conclusions. Once again, this is likely due to the absence of scientific method in the NGSS.

VII. Political Indoctrination

The doctrines of sustainability and human-caused climate change are replete in the NGSS. In fact, they are so conspicuous that it would be impossible for even a disinterested reader to miss. This hails back to the United Nations *Agenda 21* [13] document signed by President George H. Bush, and President Bill Clinton's Council on Sustainable Development document known as *Sustainable America* [14]. These two documents avow to restructure education to indoctrinate unsuspecting schoolchildren, and ultimately society as a whole, with principles of sustainable development and climate change. It can be no coincidence or surprise that the NGSS are rife with politically charged dogma, and to guarantee that this dogma is sealed in the minds of schoolchildren, the NGSS are written in a format that elevate their underlying assumptions to the level of empirically tested evidence. Furthermore, it is revealing that the Framework document upon which the NGSS were based originated from the **Division of Behavioral and Social Sciences and Education** within the National Academies of Sciences, Engineering, and Medicine.

<u>Examples of political indoctrination embedded in a standard:</u>

Example #1

> "MS-ESS3-4. Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.
>
> [Clarification Statement: Examples of evidence include grade-appropriate databases on human populations and the rates of consumption of food and natural resources (such as freshwater, mineral, and energy). Examples of impacts can include changes to the appearance, composition, and structure of Earth's systems as well as the rates at which they change. The consequences of increases in human populations and consumption of natural resources are described by science, but science itself does not make decisions for the actions society takes.] [15]

Note the words "consumption," "impacts," "changes," and "consequences" in this standard and its accompanying clarification statement. The implication is that humans impact the earth negatively; consequently, the political doctrine of sustainability is reinforced.

Example #2

> "MS-ESS3-5. Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century." [16]

Notice the underlying assumptions that (1) global warming has occurred over the past century, and (2) there is accurate and reliable evidence of this. Whether or not global warming has indeed occurred over the past century is not even the point here. Students are asked to simply "clarify" the evidence, leading them to assume that global warming is verified fact based on trustworthy data ("evidence"). If the NGSS had affirmed the need for the scientific method to discover empirical evidence, a standard related to climate change would read very differently.

Example of political indoctrination embedded in clarification statement:

> "4-ESS3-1. Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.
>
> [Clarification Statement: Examples of renewable energy resources could include wind energy, water behind dams, and sunlight; nonrenewable energy resources are fossil fuels and fissile materials. Examples of environmental effects could include loss of habitat due to dams, loss of habitat due to surface mining, and air pollution from burning of fossil fuels.]" [17]

The topic is apparently "good" renewable energy, predictably wind and sunlight. A more useful discussion of energy would focus on issues of power density and land use, comparing the ratio of total footprint to energy produced: energy conversion (wind and sunlight) vs. fossil vs. nuclear, where the poorest ratio is found in energy conversion systems. An honest evaluation would also show impacts from solar panel/wind turbine manufacture and operation as part of a comprehensive comparison among energy sources and the respective efficiencies.

VIII. Soft "Science" vs. Hard Science

Fordham's review of the NGSS identified the lack of math content as yet another weak and undesirable component of the standards. Unfortunately, in line with the problems created by questionable content, clarification statements, and assessment boundaries, math education is not only missing in the NGSS, it has been replaced by a preference for qualitative analysis, or subjective judgment, in critical areas. Why is that? If the NGSS and Common Core State Standards are supposed to be the ultimate corrective force for what ails American education, why would the desirable early (and frequent) exposure to math tools be relegated to second best?

In reading the entire NGSS document, suspicions are confirmed that national standards are merely the latest pipe dream of the "Educational Industrial Complex." This becomes remarkably clear when we evaluate the NGSS in terms of the influences of the "social" (soft) sciences. Apparently, quantitative analysis is often seen as being too limiting or restrictive, while impressions, opinions, and the ever-present "feelings" are much more "human" and "social."

Certainly, conducting genuine hard science requires skills, discipline, and appropriate balance using both quantitative and qualitative methods. Unfortunately, the NGSS miss numerous quantitative learning opportunities with some 26 directives favoring "qualitative" analysis over "quantitative." These are wasted opportunities to effectively bring numeric concepts and tools to students, particularly in the younger grades where math familiarity and competence are critical for future success.

<u>Examples of qualitative analysis favored over quantitative analysis:</u>

Example #1

> "1-ESS1-2. Make observations at different times of year to relate the amount of daylight to the time of year.
>
> [Clarification Statement: Emphasis is on **relative comparisons** of the amount of daylight in the winter to the amount in the spring or fall.]
> [Assessment Boundary: Assessment is **limited to relative amounts of daylight, not quantifying the hours or time of daylight**.]" [18] [Bold added]

Which is more useful to a student – "I think/feel the days are shorter in the winter" – or determining length of seasonal daylight/darkness and incorporating sunrise/sunset data as evidence?

Example #2

> "2-ESS2-2. Develop a model to represent the shapes and kinds of land and bodies of water in an area.
>
> [Assessment boundary: Assessment **does not include quantitative scaling in models**.]" [19] [Bold added]

This is a missed opportunity to measure landforms, incorporate map reading, introduce Google Earth use, etc. – useful and enjoyable for 2nd graders.

Example #3

> "4-PS3-1. Use evidence to construct an explanation relating the speed of an object to the energy of that object.

> [Assessment boundary: Assessment **does not include quantitative measures** of changes in the speed of an object **or on any precise or quantitative definition** of energy.]" [20] [Bold added]

Differences are important. Measurement, data, and the resulting information, not opinion, are used to determine and understand those differences.

IX. The Problem of Integrated Sciences in High School

The NGSS at all grade levels are integrated, meaning that the subject headings (called "disciplinary core ideas") are grouped into four domains: physical sciences, life sciences, engineering, and earth and space sciences. These domains are then expected to be taught *in each grade* level.

In grades K-8 this is not problematic, but at the high school level it creates some difficulties. For the state that requires three years (units) of science for graduation, it is easy to specify what exactly constitutes a one-year course in the traditional format. Ordinarily, stand-alone courses in physical science, biology, and chemistry or physics (or courses approved as suitable substitutions) are offered. However, with engineering and earth and space sciences added, physical science severely reduced, and chemistry and physics removed, the traditional stand-alone courses do not exist with the NGSS. Instead, each of the four domains is taught within each academic year. The result is that each domain will be given short shrift compared to the full year devoted to it under the traditional model.

Consider how this would work. Unless a high school science teacher is qualified to teach across all domains (e.g., a biology teacher also teaching earth and space science), the most practical solution would be to have teachers "team teach" the content. A biology teacher, for example, would probably teach a nine-week block of 9th-grade life science, then a nine-week block of 10th-grade science, and again a nine-week block of 11th-grade science. Unless students are required to complete a fourth year of science for graduation, this means only three nine-week blocks, which is one-quarter less life science instruction than offered in the traditional high school biology course.

Even if it is possible for the four domains to be condensed into three years, which would ensure that all the high school standards are covered, the depth of instruction is then questionable. Scheduling issues, when trying to ensure that one teacher can teach across grade levels, would present some feasibility challenges for schools and districts, especially those where the upper grades may be housed in different locations. One gets the impression that the creators of the NGSS have no practical experience in running a school.

X. Differences in Pedagogy: Performance vs. Content Standards

The NGSS are written as performance standards ("what *can you do?*") rather than content standards ("what *do you know?*"). A good standard should clearly convey both the essential knowledge to be learned *and* the necessary practices. The NGSS sacrifice content for performance, with project learning being central to the science classroom. Hands-on projects are important, and make learning enjoyable, but a disproportionate focus on projects results in a haphazard teaching and learning process. Disregard for the importance of building an adequate knowledge base and memory ("scaffolding") before hands-on practices results in a fly swatter approach to science education that is somewhat fragmented at best and completely disorganized at worst.

Without an expectation that students will learn, store, and master important content, two important questions emerge. Is it possible to (1) objectively and accurately evaluate a student's progress (i.e., issue a grade), and (2) evaluate the student's readiness to move on to higher level science reasoning? In fact, without requiring sufficient content learning, one must wonder if students will even learn correct science vocabulary terms. In the NGSS classroom, the teacher is merely the "guide on the side" while kids work on projects for days or weeks at a time. Implementation of the NGSS is thus a way to codify project learning in place of traditional science education pedagogy. The Fordham reviewers expressed concern about the predominance of practices over content:

> Unfortunately, the NGSS suffer from the belief - widespread among educators - that practices are more important than content. Consequently, every standard in NGSS articulates a practice first, even when doing so obscures the content that students should learn. And, while there are stand-alone standards that list practices and skills that students must master, there are no stand-alone expectations that list - in clear teacher-friendly language - the content that students should learn. Throughout the NGSS, content takes a backseat to practices, even though students need knowledge before they'll ever demonstrate fluency or mastery of scientific processes. [21]

XI. Unbalanced Content

One of the hot-button issues in public-school science instruction is, of course, how it handles the topic of evolution. While previously taught in science courses throughout the nation, evolution is given a much more prominent place in the NGSS. Furthermore, the NGSS present all concepts in evolutionary process as irrefutable factual knowledge in the science disciplines with overwhelming empirical evidence rather than as a theory with (1) strong supporting but not conclusive evidence, and (2) a competing theory (Intelligent Design) which also has supporting evidence and offers some disconfirming or refuting evidence for evolution.

The pretense among elitists in science that multiple worldviews through which we see and examine evidence (1) do not exist, or (2) are mutually exclusive, is disingenuous. Intellectual honesty in science, as with all disciplines, should always reign supreme, with admission from both sides that there is supporting and refuting evidence for any and all theories. The pursuit of truth through the scientific process in the most unbiased way possible is absolutely essential in the scientific disciplines. Guiding a student through multiple theories, each with some confirming and disconfirming evidence, will lead to better understanding of the process of inquiry and reasoning in science. This is not a new argument, but it is one that bears repeating.

Perhaps a greater concern is the amount of attention given to evolution in the standards. This topic constitutes 29% of the K-8 standards and 25% of the 9-12 standards, calculated by the actual number of standards dedicated to this content. It is neither necessary nor reasonable to devote so much time to this one subject at the expense of more essential science content, such as the human body, electrical systems, or chemistry. This is yet another example of imbalance of priorities evident in the NGSS.

XII. Cognitive Dissonance: The Empty Promise of STEM Preparation

There has been a great deal of discussion in academic and workforce planning circles regarding the need for science, technology, engineering, and mathematics (STEM) K-12 preparation for college bound students. Indeed, even the 1983 publication *A Nation at Risk*[20] painted a dire picture of math and science education in American schools.

Accordingly, the NGSS Executive Summary clearly states, “The NGSS are focused on preparing students for college and careers.” [22] The obvious assumption here is that students will be prepared for STEM careers if they choose a collegiate path. The Introduction section of the same document further states,

> Implementation of the NGSS will better prepare high school graduates for the rigors of college and careers. In turn, employers will be able to hire workers with strong science-based skills, not only in specific content areas, but also with skills such as critical thinking and inquiry-based problem solving. [23]

But this very same document later states,

> The NGSS do not define advanced work in the sciences. Based on review from college and career faculty and staff, the NGSS *form a foundation* for advanced work *but students wishing to move into STEM fields should be encouraged to follow their interest with additional coursework.* [24] [Italics added]

These conflicting statements reveal cognitive dissonance on the part of the NGSS authors. They also reveal what amounts to deception of high-school students. Those students are entitled to expect that these shiny new science standards will prepare them for college-level science coursework, but the NGSS authors apparently want them to read the fine print and pursue advanced high school courses. How many high school students will recognize the serious deficiencies in their science education? Students – and their parents - should be able to depend on their primary and secondary education to provide them with the prerequisite knowledge and skills to succeed in their college major.

Besides lacking STEM preparation, can these science standards even be considered *life* preparation? For example, simple electrical circuitry, something we encounter in our daily life, is mentioned only once in an elementary school standard; it is therefore not likely that students will emerge from their K-12 education with an understanding of this and similar fundamental concepts that could prove critical. Everyone should have an understanding of electrical circuits, if for no other reason than safety in the home. But the NGSS apparently couldn't find room in all the evolution discussion to mention such rudimentary concepts.

Additionally, there is a disconnect between the high school engineering standards and the essential math and physics content that will allow a student to grasp engineering concepts. Without the requisite physics content, engineering can only be given a cursory nod. Likewise, the delay of algebra in the Common Core mathematics standards results in the higher-level math being pushed so late into high school that vital pre-calculus and calculus comprehension and ability are missing when a student is learning the high school level engineering. In fact, the science and engineering practices for the high school engineering standards specify that students must use trigonometric functions – which are nowhere to be found in Common Core math.

This misalignment results in what amounts to an "engineering appreciation" class rather than a course in which students engage in mathematical computations required in engineering. The NGSS's boast that it teaches students engineering is thus exposed as mere propaganda.

XIII. Concluding Remarks

Proponents of the NGSS assume that content missing in the NGSS will be taught at the collegiate level, and is therefore unnecessary science content for the high school student. This is manifestly bankrupt assumption.

First of all, repetition is beneficial, indeed critical, in education at all levels. This is why the Disciplinary Core Ideas are repeated in K-5, middle school, and high school in the NGSS. Omitting massive amounts of traditional high school science content with the claim that it will be learned later in college is educational malpractice. Providing high school students with at least a basic understanding of science concepts will establish the foundation for more complex science concepts at the collegiate level and beyond. Moreover, college professors should not be expected to teach high school level science content in order to fill in the gaps, nor do they have the class time to continually review basic concepts. If they are forced to do so, the course would be considered remedial, which proponents of Common Core and the NGSS claim they are trying to prevent.

And what about students who do not go on to college? They would then never be exposed to fundamental scientific concepts that their parents and grandparents took for granted. A cynic might suspect that the NGSS authors had an agenda other than truly educating students about real science.

In summary, the NGSS is lacking in essential science content. Page 1 of the *Framework for K-12 Science Education*, which was the foundation for the NGSS, summarizes the intended goal of the standards:

> *The* ***overarching goal*** *of our framework for K-12 science education is to ensure that by the end of the 12th grade, all students* ***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.*[25] [Italics and bold added]

This "overarching goal" makes it quite clear that the NGSS are intended to be a set of *science appreciation standards* rather than rigorous educational standards.

State education departments and boards of education need to carefully consider the numerous deficiencies in the NGSS before adoption and implementation. The content errors, numerous omissions, imbalance in content, feasibility concerns with implementation of integrated standards, obvious political dogma, and major shift in pedagogy should give decision-makers pause before jumping onto the NGSS train. To adopt an entirely new set of standards without any evidence of success through pilot testing is a dangerous educational experiment that has the potential to limit students in future collegiate STEM career majors.

American schoolchildren and their education are not political chess pieces in tabletop games of climate justice and social engineering. They must be allowed to question, to investigate through prevailing and accepted methods, and to confirm to their own satisfaction, in order to truly understand their world.

Robert Heinlein, a keen observer of the human condition and one of the greatest science fiction writers of all time, authored the following now famous quote, which summarizes our concerns with NGSS well:

> One can judge from experiment, or one can blindly accept authority. To the scientific mind, experimental proof is all important and theory is merely a convenience in description, to be junked when it no longer fits. To the academic mind, authority is everything and facts are junked when they do not fit theory laid down by authority.

The crux of the matter is this: Teaching junk science produces junk scientists.

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