

**Science TEKS Drafts Feedback**  
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My comments on the Science TEKS Drafts will follow the questions we were asked to address plus some critical comments that cannot neatly fit into a single category. The comments are separated into: A: Grades K-4; B: Grade 5, C: Grades 6-8, and D: Grades 9-12. I separate Grade 5 from the first group because I find a considerable increase in sophistication and specificity in TEKS expectations at this level.

**A: Grades K-4**

- (1) *Do the TEKS insure that scientific concepts are presented in an accurate and factual manner?* Because so much of the learning objectives are vague, this is a difficult question to answer. The introductions for all four grades, for example, repeat the mantra that “science is a way of learning about the natural world.” The teacher is not instructed to help students begin to distinguish how science actually differs from other ways of learning: we use our senses daily to learn about the natural world; how are these used in science? Since this is repeated, teachers have no guidance to discriminate K from 1, 2 from 4, etc. Also repeated are (a)(4) and (a)(5). The scientific goals are vague here as well. The terms “systems”, “change”, “constancy” and “patterns” are confusing without specific denotations. What exactly is meant by “investigation”? It is obvious that kindergarten students must learn scientific concepts at a less sophisticated level than 4<sup>th</sup> graders, and the substantive topics which follow do not uniformly identify these, although many do so in an appropriate way, as I will note.
- (2) *Is a complete and logical development of scientific concepts for each grade level or course followed?* Largely the few concepts which are described do follow a good hierarchy, but many do not. In K, for example, under (5)(a) and (b), how are students to understand mass? In the “earth and space” theme, there is almost no sense of progressively sophisticated science concepts. In K, (8)(C) students “identify events that have repeating patterns including seasons of the year and day and night”; In Grade 1 (8)(D) the identical wording appears as a learning objective! In Grade 2 (8)(E) the student will “observe, describe, and record patterns in the night sky including sunrise/sunset and the observable shape of the moon.” The student in Grade 3 (7)(F) will “construct models of that [sic] demonstrate the relationship of the Sun, Earth, moon system including orbit, position, and relative size”. Finally, in Grade 4 (9)(A) the student will “identify that [sic] changes occur on a regular basis such as changes in the moon, night and day and the seasons” and (9)(B) “compare and contrast the relative size, position and motion of the Earth, moon and planets....” All of these objectives are the same! When does the student learn the cause of the seasons and the source of the moon’s phases? Ironically, the same Grade 3 students are describing energy flow in a food chain and Grade 4 students will “identify gravity as a force that keeps the planets in orbit around the sun,” both commendable and grade-appropriate goals. So we have a great inconsistency here.

Under Grade 4, (6)(E) the student studies light reflection, refraction and absorption, but there is no mention of the composition of light. Here is an ideal

place to let the students replicate Newton's prism experiments! This is a central scientific concept.

Under Grade 4, (7)(F) the student will "use models to observe fossils in rock layers." Where do they learn what fossils are and how they form? Here is an ideal place to introduce students to stratigraphy and the discoveries/experiments of Hutton and Lyell! Another central scientific concept.

- (3) *Have the correct science vocabulary and terminology been used?* What vocabulary is present is appropriate. I find curious omissions, though. As noted above, the term "mass" is used throughout but never defined as a term for a learning objective. The term "inertia" is never used at all, but I can't foresee teaching a 4<sup>th</sup> grader about force and motion without introducing the concept. The "water cycle" is mentioned in passing (Grade 3, (7)(E)) but never described nor used as a learning objective. Energy flow in the food chain, as identified by these 3<sup>rd</sup> graders, should include the water cycle. "Adaptation" is used but never defined as a scientific term (Grade 4, (a)(5)).
- (4) *Are the science process skill statements written at the appropriate grade level or course?* No. In numerous places in K-4 skills objectives, the students are expected to "investigate", "make inferences", "interpret", and "predict". These are subtle but critical processes in the conduct of science and need to be carefully elaborated for teachers of K-4, so that students in grades beyond will have a clear understanding of how science and non-science differ. They are also asked to "explain" and "justify" without being instructed in how a prediction or an inference can be tested. They are asked to "communicate valid oral and written results supported by data" (Grade 4 (2)(F)). Which results would be invalid?
- (5) *Are the science concept/content statements grade-level appropriate?* Not always; see the answer to (3) above. "Mass" is far too sophisticated for K (5)(A),(B). On the other hand, in Grade 4 (5)(C), asking the student, once again, to "compare and contrast a variety of mixtures and solutions, such as rocks in sand, sand in water, or salt in water..." is trivial and deserving only of K and 1 levels. Better here to introduce the concepts of suspension, saturation, and supersaturated solutions.
- (6) *Do the Science TEKS have Student Expectations that are aligned with the knowledge and skills?* Yes, largely, but as noted above, many are vague or incomplete and some are not grade-level appropriate – either too sophisticated or too trivial.
- (7) *Are student expectations clear and specific?* In numerous cases they are not: In later grades, the student is asked to "identify" and "differentiate", which is clear and explicit. In K-4, the student is often asked to "investigate" (exactly what does this mean?), to "ask questions about" (with no guidance implied), and "examine". These are hardly helpful to a teacher.

## **B: Grade 5**

- (1) *Do the TEKS insure that scientific concepts are presented in an accurate and factual manner?* Concepts related to changes in biological systems constitute the addition here; otherwise, a good many of the same concepts, skills, and learning objectives are repeated from the earlier grades. These new concepts include the introduction of cyclical process in ecology (differentiating producers, consumers, and decomposers) to the previous treatment of energy flow. This is excellent.

(Grade 5, cont'd) The other innovation is the introduction of the concepts of “adaptation” and intergenerational (or deep) time through fossil layers. These latter are woefully incomplete, as will be noted below.

- (2) *Is a complete and logical development of scientific concepts for each grade level or course followed?* Too many are stuck at K-4 levels. For example, under Matter and Energy (6)(A) the wording is changed but the same concepts remain – still nothing about colloidal suspensions, saturated or supersaturated solutions. Under Force, Motion, and Energy (7)(A) the same differentiation among light, heat, electrical, etc. is listed. It’s time here to introduce transformation of energy, e.g., heat to light, electrical to mechanical. In (7)(C) we see a minor change on the more advanced objective of the way light travels, but Newton’s “Optiks” is still not introduced. In Earth and Space, the student once more explains the role of the ocean in the water cycle. In Earth and Space, the student is again stuck with understanding the revolution and rotation of the earth, but we at last have the explanation of the seasons (nothing about the moon’s phases).
- (3) *Have the correct science vocabulary and terminology been used?* Yes, but the vocabulary ought to be increased.
- (4) *Are the science process skill statements written at the appropriate grade level or course?* Not all of them. The scientific reasoning section (2) is excellent except for (F), which is a repetition from earlier grades, and (3)(B) and (C) are also repeated. But (3)(A) is different and deserves comment. It asks the student to “analyze, review, and critique scientific explanations, including hypotheses and theories, as to their strengths and weaknesses using scientific evidence and information.” The “strengths and weaknesses” phrase was common to the earlier standards and has been changed in the pre-high school grades except for this one. It should also be eliminated here.

The strength of any hypothesis is its provisions for falsifiability, and without this it, technically, is not a hypothesis! As to “theory”, this will be very difficult using current theories, because the careful analysis of the legitimate ones requires more sophistication than the student will be capable of.

As a process skill for the 5<sup>th</sup> grade, however, the teacher can use any of a large number of *earlier* theories which have since been altered or discredited, because the new evidence which disfavors them can be carefully evaluated. Examples range widely: The Ptolemaic theory of a geocentric universe v. the Copernican theory; the Galilean theory of mass and acceleration; Priestley’s original phlogiston theory of combustion (coherent in both logic and physical evidence) and Lavoisier’s oxygen theory; Schleiden’s classical theory of how cells originate v. the modern theory of Virchow. These are all understandable by 5<sup>th</sup> graders, and each has strengths and weaknesses.

- (5) *Are the science concept/content statements grade-level appropriate?* The new ones stop short of good science concepts.

Under Earth and space (8)(A) the student will “draw conclusions about the past using data such as from [sic] Texas land and marine fossils and sedimentary rock sequences.” What preparation will the students have in drawing conclusions? What scientific concepts about changes in the past or

even about measuring (dating) the past will they be provided? This is an important topic and needs fleshing out in a more explicit scientific manner.

Under Earth and space (11)(B) the student is asked to “sequence past events that led to the formation of soils and fossil fuels”. This would be an excellent opportunity to talk about the concept of fossil formation and the formation of stratigraphic layers, a natural sequence of concepts from (8)(B).

Under Organisms and environments (12)(A), students are asked to “explain how organisms use their adaptations to modify their environment to insure future survival”, the examples being the use of beaver tails and rodent burrowing. This is a good place to introduce natural variations in animal features and how some variations are particularly adaptive while others can lead to extinction when environment changes. This is not too early to have them identify such variations, a classical concept in biology.

- (6) *Do the Science TEKS have Student Expectations that are aligned with the knowledge and skills?* Yes, largely, but as noted above, many are incomplete and some are below grade-level.
- (7) *Are student expectations clear and specific?* Many of them are – much better than in K-4.

### **C: Grades 6-8**

- (1) *Do the TEKS insure that scientific concepts are presented in an accurate and factual manner?* There are numerous important scientific concepts that are alluded to but never mentioned. These need to be explicit and better developed. For example:

*Homology/analogy:* Grade 6 (3)(E), (12)(B); Grade 7 (12)(E)

*Laws of Thermodynamics:* Grade 6 (8)(C)

*Inverse Square Law:* Grade 6 (11)(C). This grade level can certainly introduce the concept, and it ought to proceed in more generalized theoretical terms in grades 7 and 8, but there is no similar concept-related activity in these grades. This is a shame: the law proceeds from the Newtonian gravity concept to apply to light, sound, and other physical phenomena. It is a fundamental concept in physics.

*Mechanical digestion (?):* Grade 7 (6)(C) states “investigate how matter can undergo a physical change such as mechanical digestion.” While this term is used frequently, it is erroneous. Digestion is the chemical alteration of food to allow absorption. It begins in the mouth with enzymes, although mechanical chewing accompanies it.

*Homeostasis and disequilibrium:* Grade 7 (3)(E)(i). The concept is discussed without naming it or developing its nature. Missed opportunity.

- (2) *Is a complete and logical development of scientific concepts for each grade level or course followed?* Yes, except for those listed above, and some missed opportunities. In several places, such as Grade 7 (a)(3)(B) and (a)(3)(E)(iii) the circulation of blood is discussed as a strand. Here is where a discussion of William Harvey’s important discovery is needed, along with a discussion of earlier theories.
- (3) *Have the correct science vocabulary and terminology been used?* The vocabulary ought to be enriched, including the terms noted above.

(4) *Are the science process skill statements written at the appropriate grade level or course?* The goals in Grade 6 (a)(3)(A) i-iii are excellent, but they are repeated verbatim for grades 7 and 8. These goals should be progressively more advanced and sophisticated. For example, students somewhere in this sequence should be introduced to the kinds of questions which science *cannot* ask or answer, and they should learn why.

In Grade 6 (7)(A) I find the statement “Locate an object within its frame of reference.” What does this mean?

(5) *Are the science concept/content statements grade-level appropriate?* Yes, but appropriate concepts need to be named. The most glaring need is to make explicit the history of evolutionary concepts and the contributions by Darwin, Wallace, and others. The term evolution is not even used, although its handmaiden, natural selection, is. This is obvious in Grade 7 (a)(3)(E)(ii), where the Mendelian principles most certainly need to be introduced. This is more specifically needed later in (b)(11)(B-D), and in Grade 8 (11)(C).

(6) *Do the Science TEKS have Student Expectations that are aligned with the knowledge and skills?* Yes.

(7) *Are student expectations clear and specific?* Yes, but some are very confusing, as in (4) above. Also, in Grade 6 (b)(11)(B): “Identify characteristics of the components of the solar system.” What can this possibly refer to? And Grade 7 (b)(9)(A): “compare the characteristics of the Earth to objects in the solar system that allow life to exist.” I was unaware that we had discovered any.

#### **D: Grades 9-12 (IPC)**

(1) *Do the TEKS insure that scientific concepts are presented in an accurate and factual manner?* Yes

(2) *Is a complete and logical development of scientific concepts for each grade level or course followed?* Under (c)(4)(A), the concept of harmonic motion using the pendulum needs to be inserted. This involves three progressive ideas: the concept of force, demonstration of the rotation of the earth, and the measurement and graphing of the time period of motion. Furthermore, discussion of Galileo’s chandelier at Pisa will provide a compelling and relevant history of science.

Under (c)(7)(C) should be introduced isotopes and radioactive decay.

(3) *Have the correct science vocabulary and terminology been used?* Yes.

(4) *Are the science process skill statements written at the appropriate grade level or course?* Generally, yes. However, in the important process of asking, observing, formulating testable hypotheses, etc. there seems to be no provision for actually testing, how to establish null hypotheses, and the difference between confirming and falsifying. The expectation under ©(3)(A) is inadequate.

(5) *Are the science concept/content statements grade-level appropriate?* Yes, except as noted above.

(6) *Do the Science TEKS have Student Expectations that are aligned with the knowledge and skills?* Yes.

(7) *Are student expectations clear and specific?* Yes, except as noted above.

### **Grades 9-12 (BIO)**

- (1) *Do the TEKS insure that scientific concepts are presented in an accurate and factual manner? Yes.*
- (2) *Is a complete and logical development of scientific concepts for each grade level or course followed? Yes, with some omissions. Under (c)(6)(G) Mendelian principles of segregation and independent assortment need to be included; under (c)(7)(C) differences between mortality and fertility in selection should help clarify the concept, and Malthus' influence should be inserted. In this whole section names of the originators of the concepts are missing. Missing concepts include succession and adaptive radiation in the evolution of species, the importance of fossils, and the concept of time in evolution. These omissions make the treatment of evolution very limited and thus incomplete. For instance, if the student "knows evolutionary theory is an explanation for the diversity of life," the student should certainly also know that it is an explanation for the emergence of species*
- (3) *Have the correct science vocabulary and terminology been used? Yes*
- (4) *Are the science process skill statements written at the appropriate grade level or course? Yes. Under (b)(5) including the NAS statement on the conduct and nature of science is commendable. It needs to be placed in the other courses as well!*
- (5) *Are the science concept/content statements grade-level appropriate? Yes*
- (6) *Do the Science TEKS have Student Expectations that are aligned with the knowledge and skills? Yes*
- (7) *Are student expectations clear and specific? Yes. They just don't go far enough. The student who does not take the ESS course will miss the entire scientific field of paleontology and the long sequence of fossils reflecting life's sequence and diversity. It should be treated here as well.*

### **Grades 9-12 (Chem)**

In (c)(3)(A) we once again see the "strengths and weaknesses" clause, applied equally to hypotheses and theories without distinguishing these. Chemistry teachers need to be told exactly what the drafters have in mind here. There is a real danger of conflating the two to imply that theories have not already been subject to testing via the hypotheses which helped to frame them. This misleading phrase ought to be eliminated.

### **Grades 9-12 (Phys)**

I have no issues with the Physics course. From my level of general knowledge I find it quite adequate. I am surprised, however, not to find anything on quantum or high-energy physics and not a word about Einstein's general and special theories.

### **Grades 9-12 (EnvSys)**

I have no issues with the Environmental Systems course. I am particularly pleased with the inclusion of pollution and global warming in a more than trivial manner.

**Grades 9-12 (Aqua)**

I have no issues with the Aquatic Science course. From my level of general knowledge I find it quite adequate. I note, however, that this course and the environmental systems course share numerous ecological concepts as well as analytical procedures. In a general ecology course, it is standard to include riparian habitats and ecological zones, including streams, lakes, and marshes. The non-overlapping areas, however, probably justify the two separate courses.

**Grades 9-12 (Astro)**

In (c)(3)(A) we once again see repetition of the “strengths and weaknesses” clause from chemistry, applied equally to hypotheses and theories without distinguishing these. Astronomy teachers need to be told exactly what the drafters have in mind here. There is a real danger of conflating the two to imply that theories have not already been subject to testing via the hypotheses which helped to frame them. This misleading phrase ought to be eliminated. Students do, however, need to learn what an adequate hypothesis test is.

Some of the other concepts, such as the cause of seasons and lunar phases, are largely repetitive of those introduced back in the K-5 and later grades. Surely high school students can get far beyond this!

**Grades 9-12 (ESS)**

I have no particular issues with the Earth and Space Science course. Either here or in the Astro course, or perhaps both, should be included the tilt-and-wobble theory of earth’s changing seasonality through time, the Milankovic cycles, the K-T boundary, and the origin and features of the Quaternary. The course ought to put stress on the evolutionary history of the earth.

**Grades 9-12 (Eng)**

I have no issues with the Engineering Design and Problem Solving course. From my level of general knowledge I find it quite adequate.

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**Summary Statement**

In general, the earlier grade levels are less adequate in the specification of knowledge and skill outcomes than the later ones. This should not be the case, as the earlier achievements build towards the later. When I have mentioned particular concepts that need to be included early, as in K-4, I intend for there to be a progressive sophistication of these from a very elementary introduction to a late-grade conclusion.

I am chagrined in general at the brevity and incompleteness of the treatment of evolution. This is one of the central paradigms of biology and has positively influenced both chemistry and geology as these fields, in turn, have reinforced the scientific strength and validity of the evolutionary concept. Avoiding it is a disservice to science education.

While there was no place to include this, I am surprised to find the sections on the impact of science on society, especially the names of historic figures, to be inserted almost as an afterthought, with no particular relevance to the concepts being taught. I believe it very important to maintain a context with these. Introduce the history and the

scientists wherever you discuss the concepts they were responsible for. An understanding of historical depth in science is as important as it is in other fields.