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June 11, 2013

Stephen L. Pruitt, Ph.D. Senior Vice President, Achieve
1400 16th Street NW, Suite 510
Washington, DC 20036

Dear Dr. Pruitt:

My review of the *Next Generation Science Standards* is below, followed by a short biographical sketch.

In reviewing these standards, I compared them with other standards that I am familiar with because I was involved in their development process and used them extensively in my teacher education and curriculum development work. Those standards include:

- The previous National Science Education Standards
- The AAAS Project 2061 Benchmarks for K-12 Science Education
- The Michigan Grade Level and High School Science Expectations

I looked at standards across all grade levels and content areas, but I focused more heavily on the areas where I have published research: matter and energy, organismal metabolism, biogeochemical cycles, evolution, and climate change.

## *Focus on Core Ideas and Practices: Grade = A*

Science educators have long recognized that scientific knowledge and scientific practice are inseparable in the real world: all knowledge is embedded in practice, and all practice requires knowledge. Yet standards documents have routinely separated knowledge from practice, with separate sections or chapters for content, inquiry, nature of science, etc. NGSS does a far better job than any of its predecessors of weaving together practices, crosscutting concepts, and disciplinary core ideas in statements of performance expectations.

In addition, NGSS is based on carefully selected practices and disciplinary core ideas. The eight practices used by NGSS deserve special attention. Rather than equating "scientific practice" with "inquiry," as other standards tend to do, they recognize a full range of key inquiry, application, and communication practices. The Disciplinary Core Ideas and some of the Crosscutting Concepts also do a good job of recognizing key ideas and connecting themes in scientific knowledge.

NGSS also compares favorably with other standards on the issue of "depth vs. breadth," though in my reading it still does not go far enough. The selection of knowledge and practices is wise, but there is still more there than our science education system can deliver.

## *Rigor and Accuracy: Grade = A*

Standards consisting of long lists of correct scientific facts are not necessarily rigorous and accurate. It is important to avoid including incorrect ideas in standards documents, of course, but the primary enemy of rigor and accuracy in standards is not erroneous content. It is rote memorization.

Students respond to scientific facts that they cannot understand by memorizing words and skills that are meaningless to them. So for standards to be rigorous and accurate, they must (a) specify scientifically correct performance expectations, (b) specify performance expectations that cannot be achieved by rote memorization, and (c) specify performance expectations that are realistically achievable by students.

My view is the NGSS is excellent with respect to the first two criteria, sometimes overly optimistic with respect to the third. For example, performance expectations connected with macroscopic phenomena such as organismal metabolism are often found at the middle school level, with high school standards focusing on microscopic, atomic-molecular, and ecosystem/global scales. This understates the importance of a continuing focus on macroscopic phenomena through high school and beyond. Even with respect to this criterion, though, NGSS is as good or better than other standards documents.

## *Clarity and Specificity: Grade = A*

NGSS is less accessible to people who are not education specialists than other standards documents. The statements of performance expectations that combine knowledge and practice, the clarification statements and assessment boundaries, the color coding, and the explicit connections across content boundaries and grade levels all combine to produce a document that is hard for non-specialists to interpret.

However, what NGSS has done successfully is to develop a technical language and framework that is far clearer and more specific than other standards documents about the nature and limits of expected student performances. I believe that this is a major step forward for the field that will pay dividends as NGSS is used as a basis for assessment, research, and curriculum development.

## *Coherence: Grade = B+*

One of the good decisions made by the developers of NGSS—to combine disciplinary core ideas and practices in performance expectations—creates problems for coherence within and across grade levels. The performance expectations are necessarily selective, choosing some combinations of practices and disciplinary core ideas at the expense of others. But this selectivity creates gaps, for example where explanation is associated with a disciplinary core idea at one grade level while analyzing and interpreting data is associated with its successor at another grade level—so it is hard to track expected improvements in students' explanation practices.

The source document for NGSS, the Framework for K-12 Science Education, takes the alternate approach. By separating practices, crosscutting concepts, and disciplinary core ideas, it does a better job of showing continuity across grade levels at the expense of connections among the three strands. In combination, I think that the two documents do a fine job of showing both kinds of coherence.

## *Alignment to the Framework for K–12 Science Education: Grade = A*

It clearly was not possible to include all the details in the 400-page Framework in the NGSS. I think that the decisions about what to include and what to leave out, as well as the decisions about alternate organization, were reasonable and appropriate, as was the decision not to add content that was not in the Framework.

In summary, I feel that the combination of NGSS and the Framework are a significant intellectual accomplishment. These documents will shape both scholarship and practice in science education for many years to come.

## *Biographical Sketch*

***Charles W. (Andy) Anderson*** is Professor in the Department of Teacher Education, Michigan State University, where he has been since receiving his Ph.D. in science education from The University of Texas at Austin in 1979. Anderson's current research focuses on the development of learning progressions leading to environmental science literacy for K-12 and college students.. He has used conceptual change and sociocultural research on student learning to improve classroom science teaching and science teacher education, science curriculum, and science assessment. Anderson is past president of the National Association for Research in Science Teaching. He has been co-editor of the *Journal of Research in Science Teaching* and associate editor of *Cognition and Instruction*. He recently served as a consultant to the National Research Council's Committee on Test Design for K-12 Science Achievement and as a member of NRC's Committee on Science Learning, K-8. He served as a member of the NAEP Science Framework Planning Committee and the NAEP Science Standing Committee, and he is currently a member of NRC's Climate Change Education Roundtable.

Sincerely,

Charles W. Anderson
Professor, Science Education and Teacher Education