PISA'S 2006 Measurement of Scientific Literacy: An Insider's Perspective for the U.S.

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Presenting an insider's perspective suggests several things: clarifying the idea of scientific literacy as defined in PISA, discussing the relevant results of PISA, and clarifying meaningful relationships between PISA data and scientific competencies of U.S. students. An insider's perspective should also include some insights for contemporary science education in the United States.

PISA's 2006 measurement of scientific literacy has connections to contemporary science. Specifically, I am referring to several themes President Obama has included in his discussions of scientific issues and visions for science education. The President consistently includes themes of economic development, energy efficiency, environmental quality, health maintenance, and the importance of scientific knowledge in national policy. In science education, the President has indicated that over the next decade achievement of American students must move from the middle to the top on international assessments, including PISA. I suggest that scientific literacy, as presented in PISA 2006, the test results of U.S. students, and themes described by the current administration have clear, but challenging, implications for science education.

The essay begins with a brief discussion of scientific literacy, because that orientation presents a significant contrast to the prevailing U.S. perspective of science in state policies, school programs, and classroom practices. The discussion of relevant results of PISA 2006 Science goes beyond the "horse race" of which countries were in "win," "place," and "show" positions and presents U.S. students' science proficiencies and competencies relative to Organisation for Economic Co-operation and Development (OECD) averages. Finally, the paper concludes with a discussion of implications for contemporary science education.

What Is Meant by Scientific Literacy?

Developing a realization of what PISA 2006 Science can tell us about the performance of U.S. students begins with an insider's perspective of scientific literacy. *Scientific literacy* has become the term used to express the broad and encompassing purpose of science education. In the United States, for example, the statement "achieving scientific literacy for all students" has wide agreement and common use among educators. The use of the term in the United States most likely began with James Bryant Conant in the 1940s (Holton, 1998) and was elaborated for educators in a 1958 article by Paul DeHart Hurd entitled "Science Literacy: Its Meaning for American Schools." Hurd described the purpose of scientific literacy as an understanding of science and its applications to social experience. Science had such a prominent role in society, Hurd argued, that economic, political, and personal decisions could not be made without some consideration of the science and technology involved (Hurd, 1958).

In the 50 years since Hurd's article, scientific literacy has been used extensively to describe the purposes, policies, programs, and practices of science education. The historical perspective of scientific literacy, however, is not the reality of contemporary science education. Academic researchers debate the real meaning of the term, classroom teachers claim their students are attaining scientific literacy, and national and international assessments provide evidence that somewhere between the abstract purpose and concrete practice the science education community has failed to achieve the goal, at least in the United States.

Hurd made a clear connection between science and citizenship, yet most school science programs emphasize content and methods that represent preparation for a professional career in science. In contrast, scientific literacy, as it should be manifest in educational policies, programs, and practices, has the explicit goal of preparing students for life and work—as citizens.

Several authors have clarified the curricular orientation and instructional emphasis of scientific literacy as a purpose of science education. George DeBoer (2000) has provided an excellent historical and contemporary review of scientific literacy. Robin Millar (2006) addressed historic and definitial issues of the term before outlining the role of scientific literacy in *Twenty First Century Science*. Distinctive features of the curriculum include novel content (e.g., epidemiology, health); broad qualitative understanding—whole explanations; and a strong emphasis on knowledge about science. Two other essays stand out when discussions turn to contemporary science education and the challenges of attaining higher levels of scientific literacy in the United States. In "Science Education for the Twenty First Century," Jonathan Osborne (2007) makes a clear case that, regardless of the use of scientific literacy as a stated aim, contemporary science education is primarily "foundationalist" in that it emphasizes educating for future scientists versus educating future citizens. Among other results, Osborne argues that such an emphasis results in negative attitudes toward science.

Douglas Roberts published a chapter in the *Handbook of Research on Science Education* (Abell & Lederman, 2007) in which he identifies a continuing political and intellectual tension with a long history in science education. The two politically conflicting emphases can be stated in a question—Should curriculum emphasize science subject matter itself, or should it emphasize science in life situations in which science plays a key role? Roberts refers to curriculum designed to answer the former as Vision I, and the latter he refers to as Vision II. Vision I looks within science, while Vision II uses external contexts that students are likely to encounter as citizens.

The reader will recognize various points from this discussion in the next section on scientific literacy in PISA 2006 Science. In particular, one should note the place of contexts, scientific knowledge (including knowledge *about* science), and attitudes as they contribute to students' attainment of scientific competencies.

How Is Scientific Literacy Defined in PISA 2006?

In PISA 2006, scientific literacy referred to four interrelated features that involve an individual's

- scientific knowledge and use of that knowledge to identify questions, acquire new knowledge, explain scientific phenomenon, and draw evidence-based conclusions about science-related issues;
- understanding of the characteristic features of science as a form of human knowledge and enquiry;
- awareness of how science and technology shape our material, intellectual, and cultural environments; and
- willingness to engage in science-related issues, and with the ideas of science, as a constructive, concerned, and reflective citizen (OECD, 2006).

In PISA 2006 Science, scientific literacy was not perceived as a single discrete entity or typological classification. That is, individual students cannot be categorized as being either scientifically literate or scientifically illiterate. Rather, there is a continuum from less developed to more developed scientific competencies that include proficiency levels, different domains of scientific knowledge, and attitudes toward science. So, for example, the student with less developed scientific literacy might be able to recall simple scientific factual knowledge about a physical system and use common science terms in stating a conclusion. Students with a more developed scientific literacy demonstrate the ability to use conceptual models to explain natural phenomena, formulate explanations, evaluate alternative explanations of the same phenomena, and communicate explanations with precision.

How Was Scientific Literacy Assessed in PISA 2006?

PISA 2006 Science situated its definition of *scientific literacy* and its science assessment questions within a framework that used the following categories: *scientific contexts* (i.e., life situations involving science and technology), the *scientific competencies* (i.e., identifying scientific issues, explaining phenomena scientifically, and using scientific evidence), the domains of *scientific knowledge* (i.e., students' understanding of scientific concepts as well as their understanding of the nature of science), and students' *attitudes toward* science (i.e., interest in science, support for scientific inquiry, and responsibility toward resources and environments). These four aspects of the PISA 2006 conception of scientific literacy are illustrated in Figure 1.

The scientific contexts align with various issues citizens confront. PISA 2006 Science items were framed within a wide variety of life situations involving science and technology, primarily "health," "natural resources," "environmental quality," "hazards," and "frontiers of science and technology."

The PISA 2006 science competencies required students to identify scientific issues, explain phenomena scientifically, and use scientific evidence. These three key scientific competencies were selected because of their relationship to the practice of science and their connection to key abilities such as inductive/deductive reasoning, systems-based thinking, critical decision making, transformation of data to tables and grades, construction of arguments and explanations based on data, thinking in terms of models, and use of mathematics. Table 1 describes several features of the three competencies.

Figure 1. Framework for PISA 2006 Science Assessment

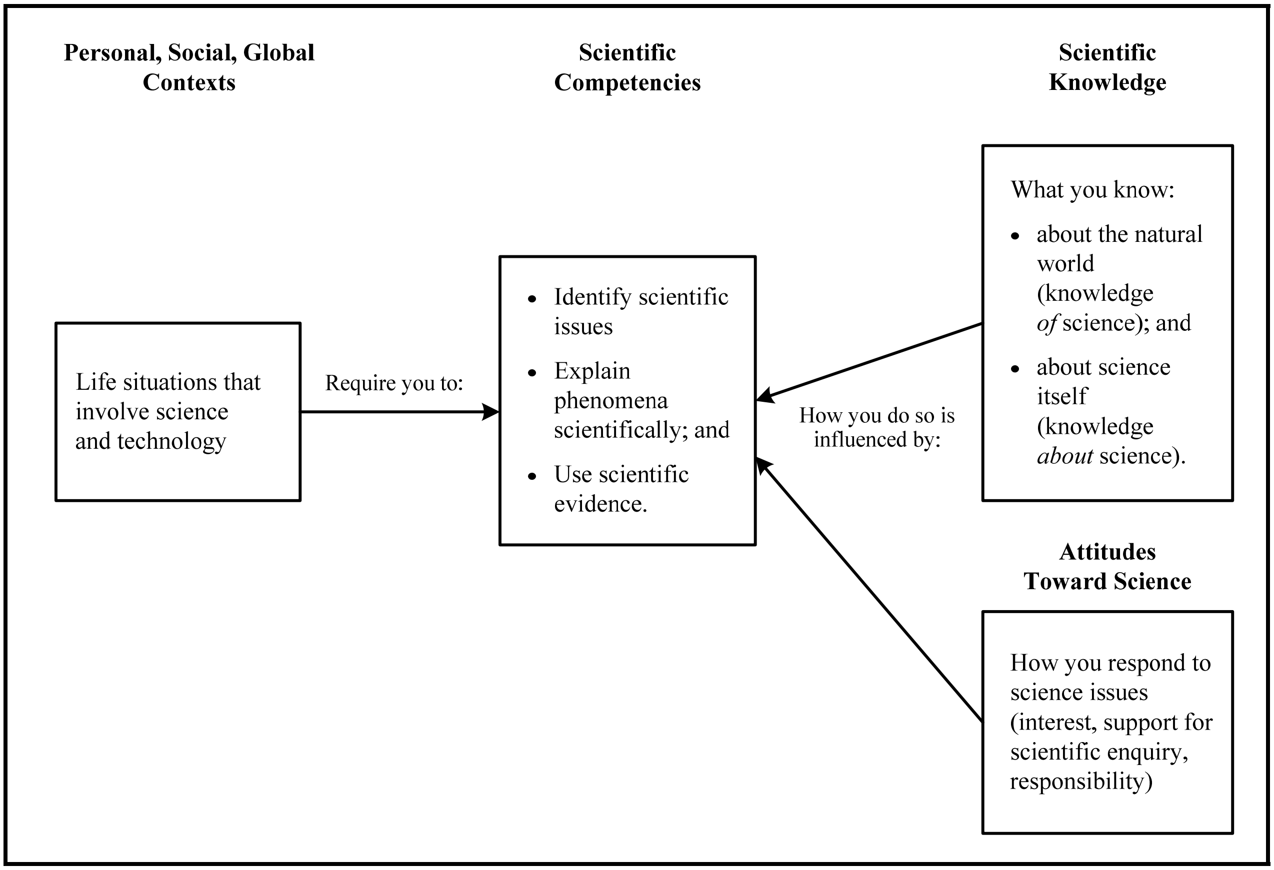

Table 1. PISA 2006 Scientific Competencies

Identifying scientific issues ▪ Recognizing issues that are possible to investigate scientifically ▪ Identifying key words to search for scientific information ▪ Recognizing the key features of a scientific investigation
Explaining phenomena scientifically ▪ Applying knowledge of science in a given situation ▪ Describing or interpreting phenomena scientifically and predicting changes ▪ Identifying appropriate descriptions, explanations, and predictions
Using scientific evidence ▪ Interpreting scientific evidence and making and communicating conclusions ▪ Identifying the assumptions, evidence, and reasoning behind conclusions ▪ Reflecting on the societal implications of science and technological developments

The scientific competencies can be illustrated with a contemporary example. Global climate change has become one of the most talked about and threatening global issues. As people read or hear about climate change, they must separate the scientific reasons for change from economic, political, and social issues. Scientists explain, for example, the origins and material consequences of releasing carbon dioxide into the Earth's atmosphere. This scientific perspective has been countered with an economic argument for continued use of carbon-based fuels and against reduction of greenhouse gases. Citizens should recognize the difference between scientific and economic positions. Further, as people are presented with more, and sometimes conflicting, information about phenomena such as climate change, they need to be able to access scientific knowledge and understand, for example, the scientific assessments of bodies such as the Intergovernmental Panel on Climate Change. Finally, citizens should be able to use the results of scientific reports and recommendations about issues such as health, prescription drugs, and safety to formulate arguments supporting their decisions about scientific issues of personal, social, and global consequence.

In PISA 2006 Science, scientific literacy also encompassed both knowledge of science and knowledge about science itself. The former includes understanding fundamental scientific concepts; the latter includes understanding inquiry and the nature of science. Because PISA describes the extent to which students can apply their knowledge in contexts relevant to their lives, assessment material was selected from the major domains of physical, life, Earth, and technology systems. Knowledge of science is required by adults for understanding the natural world and for making sense of experiences in the personal, social, and global contexts.

PISA 2006 Science used two categories for knowledge about science—"scientific inquiry," which centers on inquiry as the central process of science, and "scientific explanations," which are the results of scientific inquiry. Inquiry is the means of science (how scientists get evidence), and explanations are the goals of science (how scientists use evidence).

Attitudes toward science play an important role in scientific literacy. They underlie an individual's interest in, attention to, and response to science and technology. An important goal of science education is for students to develop interest in and support for scientific inquiry as well as to acquire and subsequently apply scientific and technological knowledge for personal, social, and global benefit. That is, a person's scientific literacy includes certain attitudes, beliefs, and motivational orientations that influence personal actions. The inclusion of attitudes and the specific areas of attitudes selected for PISA 2006 Science is supported by and builds on reviews of attitudinal research (OECD, 2006). The PISA 2006 Science assessment evaluated students' attitudes in three areas: interest in science, support for scientific inquiry, and responsibility toward resources and environment.

How Did U.S. Students Do on PISA 2006?

The PISA 2006 Science survey provided an unprecedented opportunity to compare U.S. students' scientific literacy with that of students in other countries, both our economic competitors in the OECD and 27 other countries. This discussion begins with a summary of the U.S. position among OECD countries and other non-OECD countries that participated in PISA 2006 Science. The discussion includes a review of student performance on the proficiency levels used to clarify degrees of scientific literacy on this survey.

The United States was one of 57 countries participating in PISA 2006 Science. This number includes 30 OECD countries and 27 partner countries. Students in the United States scored an average of 489 points, which is 11 points below the OECD average of 500 points. U.S. students ranked 17th among other industrialized (OECD) countries.

From the view of both a U.S. citizen and PISA insider, the U.S. trend in science is of great concern. The United States dropped from 14th in science on PISA 2000 to 19th in 2003 and 21st in 2006. Whatever the combination of other countries doing better and a decline in science education in U.S. education, the results are of concern as they relate to general scientific literacy in the United States. In practical terms, the U.S. scientific literacy translates to the supply of scientists and engineers, skilled workers, technological innovation, and ultimately economic growth.

Overall U.S. performance. To say the least, U.S. results on PISA 2006 Science were disappointing. U.S. 15-year-olds lag behind a majority of developed nations' 15-year-olds who participated in the survey. Out of 30 OECD countries participating, 16 countries' average scores were measurably higher than the U.S. average (see Table 2). The average score for Finland, the highest achieving country, was 74 points above the United States' average score. Other high-achieving countries included Canada, Japan, New Zealand, and Australia. Among non-OECD countries, six countries' average scores were measurably higher than the United States' average score: Hong Kong-China, Chinese Taipei, Estonia, Liechtenstein, Slovenia, and Macao-China (see Table 3).

Science literacy scores for racial/ethnic groups. On the combined science literacy scale, Black students and Hispanic students scored significantly lower, 409 and 439, respectively, than the OECD average (500) and lower than White (523), Asian (499), and students of more than one race (501). This pattern of performance for racial and ethnic groups was similar to that reported by PISA in 2000 and 2003 (Baldi et al., 2007; Lemke et al., 2001; Lemke et al., 2004).

Proficiency levels for scientific literacy. In PISA 2006 Science, performance levels were defined for the purpose of describing in greater detail the scientific competencies and overall scientific literacy. Student scores in science were grouped into six proficiency levels: Level 6 represents the most difficult tasks and Level 1 the least difficult tasks. The grouping into proficiency levels was undertaken on the basis of combining scientific knowledge and abilities underlying scientific competencies. Proficiency at each of the six levels can be understood in relation to descriptions of the kind of scientific competencies that students need to attain the respective levels. Table 4 summarizes the levels and represents a synthesis of individual competencies for overall science literacy. The percentage of OECD students and the percentage of U.S. students at the respective levels are displayed.

Table 2. PISA 2006 Science Survey: OECD Jurisdictions

PISA Results	Science	
Average is measurably higher than the U.S. average (dark red)	OECD average score	500
Average is not measurably higher or lower than U.S. (black)	**OECD JURISDICTIONS**	
Average is measurably lower than the U.S. average (blue)	Finland	563
	Canada	534
	Japan	531
	New Zealand	530
	Australia	527
	Netherlands	525
	South Korea	522
	Germany	516
	United Kingdom	515
	Czech Republic	513
	Switzerland	512
	Austria	511
	Belgium	510
	Ireland	508
	Hungary	504
	Sweden	503
	Poland	498
	Denmark	496
	France	495
	Iceland	491
	UNITED STATES	**489**
	Slovak Republic	488
	Spain	488
	Norway	487
	Luxembourg	486
	Italy	475
	Portugal	474
	Greece	473
	Turkey	424
	Mexico	410

Table 3. PISA 2006 Science Survey: Non-OECD Jurisdictions

PISA Results	Science	
Average is measurably higher than the U.S. average (dark red)	OECD average score	500
Average is not measurably higher or lower than U.S. (black)	**NON-OECD JURISDICTIONS**	
Average is measurably lower than the U.S. average (blue)	Hong Kong	542
	Chinese Taipei	532
	Estonia	531
	Liechtenstein	522
	Slovenia	519
	Macao	511
	Croatia	493
	Latvia	490
	***United States**	**489**
	Lithuania	488
	Russia	479
	Israel	454
	Chile	438
	Serbia	436
	Bulgaria	434
	Uruguay	428
	Jordan	422
	Thailand	421
	Romania	418
	Montenegro	412
	Indonesia	393
	Argentina	391
	Brazil	390
	Colombia	388
	Tunisia	386
	Azerbaijan	382
	Qatar	349
	Kyrgyz Republic	322

*The United States is an OECD country. It has been included in this table for comparison purposes.

Table 4. Summary Descriptions for the Six Levels of Proficiency on the Combined Science Scale

Level	What Students Can Typically Do at Each Level	Percentage of All Students across OECD Who Can Perform Tasks at Least at This Level	Percentage of U.S. Students Who Can Perform Tasks at Least at This Level
6	At Level 6, students can consistently identify, explain, and apply scientific knowledge and knowledge about science in a variety of complex life situations. They can link different information sources and explanations and use evidence from those sources to justify decisions. They clearly and consistently demonstrate advanced scientific thinking and reasoning, and they use their scientific understanding in support of solutions to unfamiliar scientific and technological situations. Students at this level can use scientific knowledge and develop arguments in support of recommendations and decisions that center on personal, social, or global situations.	**1.3%**	**1.5%**
5	At level 5, students can identify the scientific components of many complex life situations; apply both scientific concepts and knowledge about science to these situations; and can compare, select, and evaluate appropriate scientific evidence for responding to life situations. Students at this level can use well-developed inquiry abilities, link knowledge appropriately, and bring critical insights to these situations. They can construct evidence-based explanations and arguments based on their critical analysis.	**9.0%**	**9.0%**
4	At Level 4, students can work effectively with situations and issues that may involve explicit phenomena requiring them to make inferences about the role of science and technology. They can select and integrate explanations from different disciplines of science or technology and link those explanations directly to aspects of life situations. Students at this level can reflect on their actions, and they can communicate decisions using scientific knowledge and evidence.	**29.3%**	**27.3%**
3	At Level 3, students can identify clearly described scientific issues in a range of contexts. They can select facts and knowledge to explain phenomena and apply simple models or inquiry strategies. Students at this level can interpret and use scientific concepts from different disciplines and can apply them directly. They can develop short statements using facts and make decisions based on scientific knowledge.	**56.7%**	**51.3%**
2	At Level 2, students have adequate scientific knowledge to provide possible explanations in familiar contexts or draw conclusions based on simple investigations. They are capable of direct reasoning and making literal interpretations of the results of scientific inquiry or technological problem solving.	**80.8%**	**75.5%**

(continued)

Table 4. Summary Descriptions for the Six Levels of Proficiency on the Combined Science Scale (continued)

Level	What Students Can Typically Do at Each Level	Percentage of All Students across OECD Who Can Perform Tasks at Least at This Level	Percentage of U.S. Students Who Can Perform Tasks at Least at This Level
1	At Level 1, students have such a limited scientific knowledge that it can only be applied to a few, familiar situations. They can present scientific explanations that are obvious and follow explicitly from given evidence.	**94.8%**	**92.3%**
	Below Level 1	**5.2%**	**7.6%**

U.S. students at higher levels of proficiency. Scientific advances and technological innovations require a labor force with high levels of scientific literacy. Additionally, achieving and staying at the frontiers of science and technology require educated individuals with high levels of knowledge and scientific competencies. Research by Eric Hanushek (2005), for example, has shown the positive economic benefit of attaining skills one standard deviation above the mean on the International Adult Literacy Study.

At Level 6, for example, students can consistently identify, explain, and apply both knowledge of science and knowledge about science in a variety of complex situations involving science. For OECD countries, 1.3% of students perform at Level 6 on the science literacy scale. In the United States, 1.5% reach Level 6. If we consider both Levels 5 and 6, the United States is the same as the OECD average—9.0%. This is the good news. However, other countries have much higher percentages at Levels 5 and 6, for example, Finland (20.9%), New Zealand (17.6%), and Japan (15.1%). These countries have a very high potential for creating scientists and engineers and prominent scientific literacy among all citizens.

U.S. students at lower levels of proficiency. In PISA 2006 Science, Level 2 was designated as the baseline for the competencies. This is the level at which students begin to demonstrate science competencies that will allow them to participate actively as citizens. Students at Level 2 can identify key features of a scientific investigation, recall concepts, and use results of an investigation represented in a data table as they support a personal decision. Across the OECD, 19.2% of students are categorized as below the baseline, Level 2. For the United States, this average is 24.5%. Below Level 2, students may confuse key features of an investigation, apply incorrect scientific information, and confound scientific evidence with personal opinions and beliefs. These results indicate that about one quarter (24.5%) of U.S. students do not demonstrate the competencies that will allow them to engage productively in science- and technology-related life situations. This finding should be a concern to all individuals associated with science education in the United States.

Science proficiency levels for racial and ethnic groups. Black, Hispanic, and American Indian/Native Alaskan students scored below the OECD average. Scores for White students were above the OECD average. On average, the mean scores for White, Asian, and students of more than one race were in Proficiency Level 3; the mean scores of Hispanic, American Indian/Native Alaskan, and Native Hawaiian/Other Pacific Islander students were in Proficiency Level 2; and the average mean score for Black students was at the top of Proficiency Level 1 (Baldi et al., 2007).

U.S. students and science competencies. Among the unique insights gained from PISA 2006 Science is information on student performance on the three scientific competencies—identifying scientific issues, explaining phenomena scientifically, and using scientific evidence. Examining the scientific competencies individually suggests possible areas to strengthen science education. One way to think of the science competencies is in terms of a sequence that individuals might go through as they encounter and solve science-related problems. First, they must identify the scientific aspects of a problem, then apply appropriate scientific knowledge about that problem, and finally, they have to interpret and make sense of their findings in support of a decision or recommendation. Traditional science courses in the United States tend to concentrate on the middle segment—explaining phenomena scientifically—and give much less emphasis to identifying scientific issues and using scientific evidence.

On identifying scientific issues, U.S. students ranked 15th among OECD countries, but not statistically significantly different from the OECD average. U.S. students were statistically significantly below the OECD average on explaining phenomena scientifically and using scientific evidence. There were gender differences as girls performed better on identifying scientific issues and using scientific evidence and boys performed better on explaining phenomena scientifically. This finding was consistent with performance by other OECD countries.

U.S. students performing at the highest levels, 5 and 6, were about equal to the percentage of all OECD students: 9.7% for OECD students and 9.3% for U.S. students. Below the baseline, the United States had 21.6% on identifying scientific issues (see Table 5).

On explaining phenomena scientifically, the United States had slightly more students in the upper two levels of proficiency, 11.8% (U.S.) and 11.6% (OECD). However, the United States had 26.3% of students below the baseline (see Table 6).

Finally, for using scientific evidence, 13.7% of U.S. students did well by achieving at the top levels on this proficiency. However, this percentage was lower than the percentage of OECD students (14.2%). The disappointing result was at the lower level. Twenty-six percent of U.S. students were below the baseline. This is compared to 21.9% of all OECD students (see Table 7).

Table 5. Identifying Scientific Issues: Summary Descriptions of the Six Proficiency Levels

Level	Proficiency at Each Level	Percentage of All Students across OECD Who Can Perform Tasks at This Level	Percentage of U.S. Students Who Can Perform Tasks at This Level
6	Students at this level demonstrate an ability to understand and articulate the complex modelling inherent in the design of an investigation.	**1.3%**	**1.2%**
5	Students at this level understand the essential elements of a scientific investigation and, thus, can determine if scientific methods can be applied in a variety of quite complex and often abstract contexts. Alternatively, by analyzing a given experiment students can identify the question being investigated and explain how the methodology relates to that question.	**8.4%**	**8.1%**
4	Students at this level can identify the change and measured variables in an investigation and at least one variable that is being controlled. They can suggest appropriate ways of controlling that variable. The question being investigated in straightforward investigations can be articulated.	**28.4%**	**26.5%**
3	Students at this level are able to make judgments about whether an issue is open to scientific measurement and, consequently, to scientific investigation. Given a description of an investigation students can identify the change and measured variables.	**56.7%**	**53.2%**
2	Students at this level can determine if scientific measurement can be applied to a given variable in an investigation. They can recognize the variable being manipulated (changed) by the investigator. Students can appreciate the relationship between a simple model and the phenomenon it is modelling. In researching topics, students can select appropriate key words for a search.	**81.3%**	**78.4%**
1	Students at this level can suggest appropriate sources of information on scientific topics. They can identify a quantity that is undergoing variation in an experiment. In specific contexts, they can recognize whether that variable can be measured using familiar measuring tools or not.	**94.9%**	**94.4%**
	Below Level 1	**5.1%**	**5.6%**

Table 6. Explaining Phenomena Scientifically: Summary Description for the Six Proficiency Levels

Level	Proficiency at Each Level	Percentage of All Students across OECD Who Can Perform Tasks at This Level	Percentage of All U.S. Students Who Can Perform Tasks at This Level
6	Students at this level draw on a range of abstract scientific knowledge and concepts and the relationships between these in developing explanations of processes within systems.	**1.8%**	**2.0%**
5	Students at this level draw on knowledge of two or three scientific concepts and identify the relationship between them in developing an explanation of a contextual phenomenon.	**9.8%**	**9.8%**
4	Students at this level have an understanding of scientific ideas, including scientific models, with a significant level of abstraction. They can apply a general, scientific concept containing such ideas in developing an explanation of a phenomenon.	**29.4%**	**26.7%**
3	Students at this level can apply one or more concrete or tangible scientific ideas/concepts in developing an explanation of a phenomenon. This is enhanced when there are specific cues given or options available from which to choose. When developing an explanation, cause-and-effect relationships are recognized, and simple, explicit scientific models may be drawn on.	**56.4%**	**50.1%**
2	Students at this level can recall an appropriate, tangible, scientific fact applicable in a simple and straightforward context and can use it to explain or predict an outcome.	**80.4%**	**73.7%**
1	Students at this level can recognize simple cause-and-effect relationships given relevant cues. The knowledge drawn on is a singular scientific fact that is drawn from experience or has widespread popular currency.	**94.6%**	**91.7%**
	Below Level 1	**5.4%**	**8.4%**

Table 7. Using Scientific Evidence: Summary Descriptions of the Six Proficiency Levels

Level	Proficiency at Each Level	Percentage of All Students across OECD Who Can Perform Tasks at This Level	Percentage of All U.S. Students Who Can Perform Tasks at This Level
6	Students at this level demonstrate an ability to compare and differentiate among competing explanations by examining supporting evidence. They can formulate arguments by synthesizing evidence from multiple sources.	**2.4%**	**2.5%**
5	Students at this level are able to interpret data from related datasets presented in various formats. They can identify and explain differences and similarities in the datasets and draw conclusions based on the combined evidence presented in those datasets.	**11.8%**	**11.2%**
4	Students at this level can interpret a dataset expressed in a number of formats, such as tabular, graphic, and diagrammatic, by summarizing the data and explaining relevant patterns. They can use the data to draw relevant conclusions. Students can also determine whether the data support assertions about a phenomenon.	**31.6%**	**29.0%**
3	Students at this level are able to select a piece of relevant information from data in answering a question or in providing support for or against a given conclusion. They can draw a conclusion from an uncomplicated or simple pattern in a dataset. Students can also determine, in simple cases, if enough information is present to support a given conclusion.	**56.3%**	**51.8%**
2	Students at this level are able to recognize the general features of a graph if they are given appropriate cues and can point to an obvious feature in a graph or simple table in support of a given statement. They are able to recognize if a set of given characteristics apply to the function of everyday artifacts in making choices about their use.	**78.1%**	**73.9%**
1	In response to a question, students at this level can extract information from a fact sheet or diagram pertinent to a common context. They can extract information from bar graphs where the requirement is simple comparisons of bar heights. In common, experienced contexts students at this level can attribute an effect to a cause.	**92.1%**	**90.0%**
	Below Level 1	**7.9%**	**10.0%**

Scientific Literacy and Selected Implications of PISA for U.S. Science Education

In the introduction, I suggested several connections between PISA 2006 Science and contemporary reform of education. This concluding section discusses the implications of PISA for science education in general and several themes emphasized by President Obama. I use the President's clearest discussion of science and science education, the April 27, 2009, remarks at the National Academy of Sciences, as the basis for several of the implications (Remarks of President Barack Obama).

Fostering scientific literacy. In the United States, most school science programs do not emphasize scientific literacy as described in PISA 2006. To be clear, consistently the term *scientific literacy* is stated as the purpose of science education, but school programs primarily emphasize facts, information, and knowledge of the science disciplines and only secondarily emphasize the applications of science related to citizens' life situations. The difference may seem subtle, but it is basic and essential to understand.

The critical challenge centers on the difference between the two perspectives of science curriculum and teaching described earlier. One perspective is the fundamentalist and *internal* to science itself. In this perspective, educational policies, programs, or practices center on questions such as these: What knowledge of science and its processes should students have? What facts and concepts from physics, chemistry, biology, and the Earth sciences should be the basis for school science programs? In contrast, there is the *external* perspective that begins with science-related situations that citizens might encounter. When thinking about educational policies, programs, and practices from this perspective, questions center on these questions: What science should students know and be able to do as future citizens? What contexts could be the basis for introducing science and technology? The difference between these two perspectives is significant, because the emphasis of curricula, selection of instructional strategies, design of assessments, and professional education of teachers differ based on the perspectives. The learning outcomes also differ.

Based on this discussion of PISA 2006, I point out an insider's view of what is perhaps the single most significant challenge facing those who wish to foster scientific literacy in the United States. Most individuals involved in science education hold the internalist perspective that school science programs should first, foremost, and exclusively emphasize the basic knowledge and processes of science and secondarily and incidentally make some links to social issues such as health, environment, resources, and energy efficiency. If time and opportunity permit—which usually they do not—the science-related social issues might be taught.

If the United States wants to foster higher levels of scientific literacy, then it is essential to begin recognizing the perspective that includes science-related social issues and accept the importance of incorporating scientific literacy into standards for science education.

Following the President's vision would include adding science and scientific literacy to initiatives by the National Governors Association, the Council of Chief State School Officers, Achieve (2008), and others to revise and improve national, state, and local standards and assessments.

Socioeconomics and science achievement. One of the major insights from PISA 2006 Science is the fact that compared to other nations, poverty had a greater effect on PISA scores in the United States. Socioeconomic background accounted for an 18% variation on U.S. student achievement. This finding should cause alarm about the importance of scientific literacy as it relates to social inequities and the connections between social inequities and racial and ethnic groups. To be specific about what schools and science education might do, it is clear that students of lower socioeconomic status do not have the same opportunities to learn science as students in higher socioeconomic groups. The U.S. system of education does not provide underprivileged students with demanding science curricula, high-quality science teachers, and other resources such as well-equipped modern science laboratories. To place this in contemporary terms, in spite of the No Child Left Behind legislation, we are leaving some children behind, and they tend to be the less privileged.

The difficulty with the socioeconomic problem is that it is a huge, complex social problem. Schools can only contribute to changes in the larger social problem, but policy makers and educators can respond to inequities within the educational system. I refer to those mentioned above—curriculum, instruction, teachers, and the allocation of resources. The current administration has proposed $5 billion for states that make a commitment to improve math and science achievement. States will compete for these funds under an initiative titled “Race to the Top.” The double entendre of this title should not be lost in discussions that center on competitions with other countries and educational standards, curriculum, and teacher education. Reducing the discrepancies of achievement among racial and ethnic groups must be a part of contemporary reform in the United States.

A new generation of science curricula. Assuming that the themes related to scientific literacy, such as “science in personal and social perspectives” (NRC, 1996), are included in standards, then it is clear there is a need for instructional materials aligned to the standards. This represents “upgrading the curriculum.” This new generation of curriculum materials for grades K through 12 could include strategies that help students develop 21st century workforce skills and abilities in modernized laboratories for science and technology.

Let me be very clear about this implication. I would propose that this new generation of curriculum materials be designed, developed, and implemented as a complement to current programs. Rather than a complete reform of the current fundamental curriculum, the proposed new generation would account for 2 to 3 weeks of activities in the school year. These activities would give students opportunities to apply their scientific knowledge to local, national, and global problems of energy, environment, resources, and health while developing 21st century skills and abilities.

In conclusion, I have used an insider's perspective of PISA 2006 Science to provide both an orientation and rationale for reinvigorating American science education. The President has indicated the reasonable time of a decade for this reform. The results from PISA 2015, when science will again be emphasized, represent a reasonable benchmark for U.S. progress in our race from the middle to the top.

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