



MAKING THE GRADE?

How State Public School Science Standards Address Climate Change

A Report from the National Center for Science Education
and the Texas Freedom Network Education Fund

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Introduction

More than 11,000 scientists in late 2019, noting that they and their colleagues “have a moral obligation to clearly warn humanity of any catastrophic threat,” endorsed a report¹ stating “clearly and unequivocally that planet Earth is facing a climate emergency.” In fact, virtually all climate scientists say overwhelming evidence shows that human-caused climate change is real.² That consensus is evident in official statements from major scientific organizations, including the U.S. National Academy of Sciences, the American Association for the Advancement of Science, and the Intergovernmental Panel on Climate Change. “We are more sure that greenhouse gas is causing climate change than we are that smoking causes cancer,” explains one NASA atmospheric scientist.³

We can already see the effects of climate change today, as the National Oceanic and Atmospheric Administration⁴ explains. These effects include more extreme weather events such as severe droughts and destructive storms. Such weather extremes are putting increasing pressure on water supplies and on the farmers and ranchers who supply our food. Rising temperatures also lead to more heat stress and other health challenges, including poor air quality and more infectious disease. Rising ocean levels threaten coastal populations, and more acidic ocean waters threaten marine life. And the negative impacts of climate change are severe for especially vulnerable communities — including low-income communities, rural communities, and people of color — that lack the resources to recover and adapt and already experience disparate challenges in health and health care.

Despite the overwhelming scientific evidence, political debate over the reality of climate change and human responsibility for it rages on. This debate is shaping public policies, good and bad, that determine our society’s response to the emergency scientists warn about. But to what extent are public schools helping students understand what is happening and preparing them to responsibly engage in civic deliberation on the problem and possible solutions? To help answer this question, the National Center for Science Education (NCSE) and the Texas Freedom Network Education Fund (TFNEF) engaged in a comparative study of how each state’s science standards for public schools address climate change.



1 “World Scientists Warning of a Climate Emergency,” *BioScience*, January 2020, <https://academic.oup.com/bioscience/article/70/1/8/5610806>

2 The Consensus Project, <http://theconsensusproject.com/>

3 “Even Americans highly concerned about climate change dramatically underestimate the scientific consensus,” Yale Program on Climate Change Communication, October 18, 2018, <https://climatecommunication.yale.edu/publications/even-americans-highly-concerned-about-climate-change-dramatically-underestimate-the-scientific-consensus/>

4 “Climate change impacts,” National Oceanic and Atmospheric Administration, <https://www.noaa.gov/education/resource-collections/climate/climate-change-impacts>

State Science Standards

Every state has adopted and periodically revises its science standards, which identify the basic information and skills students are expected to master in their courses of study. These standards guide the content of statewide testing and assessment, textbooks and other instructional materials, and classroom instruction. Each state has its own process for writing and adopting standards.

Today 20 states and the District of Columbia use the Next Generation Science Standards, or NGSS. These NGSS states account for more than 36 percent⁵ of public school enrollment in the country. Released in 2013, the NGSS are the product of a consortium of states working together with the National Research Council, the National Science Teaching Association, the American Association for the Advancement of Science, and the nonprofit educational organization Achieve. The NGSS are based on the National Research Council's *A Framework for K–12 Science Education*, released in 2011. Another 24 states, with about 35 percent of the country's public school enrollment, have written their own standards guided by the Framework. The remaining six states, with close to 30 percent of public school enrollment, use science standards not based on the Framework.



⁵ About the Next Generation Science Standards, National Science Teaching Association, <https://ngss.nsta.org/about.aspx>

Scope of the Study

Working independently, three expert reviewers, all Ph.D. scientists with differing specialties, evaluated how climate change is addressed in the NGSS and then the standards for each of the 30 states that have not adopted the NGSS. See Appendix A for information on the three reviewers. Note: The reviewers examined only the state standards, not model curricula or other guidelines created by some states.

The reviewers considered the treatment of climate change in each set of standards with respect to four key points that form a basic outline of the scientific consensus on the issue:

1. **It's real:** Recent climate change is a genuine phenomenon.
2. **It's us:** Human activity is responsible for the global change in climate.
3. **It's bad:** Climate change is affecting and will continue to affect nature and society.
4. **There's hope:** It is possible to mitigate and adapt to climate change.

In evaluating how the standards addressed those four points, the reviewers considered six focus questions for each:

- A. To what extent is the treatment of the issue in the standards **helpful** in permitting students to reach these conclusions?
- B. To what extent is the treatment of the issue in the standards appropriately **explicit?**
- C. To what extent is the treatment of the issue in the standards **integrated** in a coherent learning progression?
- D. To what extent do the standards make it **clear** to teachers what knowledge and skills students are expected to attain?
- E. To what extent would a student who met the performance expectations in the standards relevant to the issue be prepared for further study in **higher education?**
- F. To what extent would a student who met the performance expectations in the standards relevant to the issue be prepared for responsible participation in **civic deliberation** about climate change?



The reviewers assessed the standards by answering the six focus questions — as very good (i.e., helpful, explicit, integrated, clear, preparing for higher education, preparing for civic deliberation), somewhat good, somewhat bad, very bad, or not present — with regard to each of the four key points. These responses were assigned numerical scores.

Given the different areas of specialization and approaches of the reviewers, it's not surprising that their views diverged somewhat as they evaluated each state's standards. Such evaluations are by their nature subjective. In assigning overall grades to the standards, we sought to control for these factors by weighting areas of agreement among the three reviewers more heavily. Moreover, to help make state-by-state comparisons of quality clearer, we assigned letter grades on a curve. See Appendix B for a detailed explanation of how the scores were weighted and the grades curved. While the reviewers provided their knowledge and expertise in evaluating the standards for each state, the design of the study and the final grades assigned to all of the states are entirely the responsibility of NCSE and TFNEF.

The results of this study reveal that public education policymakers in many states are failing to ensure that science standards forthrightly and accurately address climate change. The scope and character of that failure are not uniform across the country, but they expose a serious deficit in the quality of science education in the United States.

By the Numbers

A bare majority — just 27 — of the 50 states and District of Columbia have standards that earned a B+ or better for how they address climate change. Those 27 include the 20 states and DC that have adopted the NGSS. Of the remaining 24 states, 20 earned no better than a C+. Ten of those received a D or worse, and they include some of the most populous states in the country, such as Texas (F), Florida (D), Pennsylvania (F), and Ohio (D). Six states received a failing grade overall.

The NGSS earned a B+ on addressing climate change. Only six non-NGSS states earned a B+ or better for their science standards, and all six are based on the National Research Council's Framework. One earned an A, while four received an A- and one received a B+. It is important to note that the reviewers had varying degrees of concern with all of the sets of science standards they evaluated, including the NGSS. Therefore, even states receiving a final grade of A or A- for their standards should not necessarily be seen as having model standards that need no improvement. Even so, the top grades indicate that the standards in those states were superior compared to those in other states.

Interestingly, several of the states earning an A or A- for their standards have economies in which mining and fossil fuel extraction are particularly important: Wyoming, Alaska, and North Dakota.⁶ This fact suggests that even in states in which many jobs and tax dollars are substantially tied to the fossil fuel industry, education policymakers can do a reasonably good job of adopting science standards that reflect the scientific consensus about human-caused climate change and how society can mitigate and adapt to it.

⁶ "The challenges of state reliance on revenue from fossil fuel production," Brookings, August 9, 2016, <https://www.brookings.edu/research/the-challenges-of-state-reliance-on-revenue-from-fossil-fuel-production/>

Altogether, 24 states based their science curriculum standards on the Framework. In some cases, the reviewers found that such states largely replicated the NGSS. But the fidelity with which they followed the guidance from the Framework or replicated language from the NGSS varied significantly on the issue of climate change, with a number of states diluting or deleting the relevant standards. The result was that most of those standards rate poorly compared to the NGSS with respect to climate change. (The reviewers were not always in agreement, however. Arizona, a Framework state, was among two states for which reviewers had the widest divergence in their evaluations. The other was North Carolina, a non-Framework state.) In the end, 14 states that used the Framework as a basis ended up with a C+ or worse on addressing climate change. Three received an F.

Six states use science standards that are not based on the Framework. The standards of the majority of these states were adopted before the Framework or the NGSS were available: Pennsylvania's standards were adopted in 2002, Florida's in 2008, Texas's in 2009, and North Carolina's in 2010. The six non-Framework states cluster toward the bottom of the grading scale. Two states received a D and three an F.

The grades states received overall and for each category and focus question are available in the table beginning on page 8. The table also identifies the NGSS, Framework, and non-Framework states. A summary evaluation for each state is at the end of this report.

Key Findings

A number of common problems with the state science standards' treatment of climate change are evident in the reviewers' evaluations.

Promoting False Debate

A few state standards promote the false narrative that the existence, cause, and seriousness of climate change are a matter of debate among climate scientists. Particularly egregious are West Virginia's standards (which received a D overall grade), which specifically require students to debate the issue in their science classrooms. "Debate is not a normal method of science," one reviewer noted. "For what it's worth, there is not debate among climate scientists about the reality of human-caused climate change. Debating in K-12 science standards is a classic device employed by deniers (of evolution or climate change) to get their positions presented in public schools absent any (non-cherry-picked) data. Tellingly, this is the only place in the West Virginia standards that employs debate." The same reviewer was disappointed that the NGSS (B+) did not "address how students can recognize willful attempts to misrepresent climate data.... Nor do they help teachers understand how they might do this effectively for their students."

Failing to Address Climate Change Directly

The majority of state standards are clear that climate change is a real and serious global problem and that human activity is responsible for it. But the reviewers expressed concerns with a failure in many states to be explicit. In some cases, such as Pennsylvania and Virginia (each of which received an overall grade of F), the standards essentially ignore climate change altogether. In other cases, the standards address issues that are part of the problem without explicitly naming "climate change" or "global warming." Teachers are left to assess whether a particular standard offers an appropriate

opportunity to discuss the issue. “A skilled teacher who already knows and wants to address climate change can do so,” one reviewer noted (with regard to Georgia’s standards). “An inexperienced one or one confronting climate denial will have a hard time knowing how to.”

Muddling the Science

A related problem evident in many state standards is ambiguity about the scientific evidence itself. The reviewers’ comments are peppered with words like “tentative,” “vague,” “equivocation,” even “strange.” The net effect of such ambiguous wording in state science standards is to muddle the science, suggesting that the evidence on climate change isn’t as clear as it really is. For example, while the NGSS (which receive a B+ overall grade) expect students to study evidence that human activities and natural processes “have caused” a rise in global temperatures, the Alabama standards (which received an F) only suggest that such factors “may have caused” such a change. Similarly, one reviewer noted that “Utah’s standards [which received a C+] have been masterfully edited or otherwise changed to downplay if not ignore the reality, human cause, and seriousness of climate change.”

Missing Opportunities to Inspire Hope

In a number of cases, reviewers praised standards that helped students understand real-world impacts of climate change and ways to mitigate or adapt to them. The Minnesota standards (which received a B- grade overall), for example, urge students to reach out to Indigenous communities to learn about how climate change affects them and their regions. Other states usefully included standards expecting students to analyze and understand how engineering and technology solutions can help society deal with climate change. But the reviewers expressed considerable disappointment in the failure of many states to follow suit. One reviewer noted, for example, the failure of North Carolina’s standards (C-) to make sure students understand “that not only is there hope, but [also] some very meaningful and potentially rewarding career opportunities in mitigating climate change, e.g. smart grid technologies, design of more efficient transportation and housing options, installation, maintenance, and optimization of renewable energy infrastructure.” This failure was particularly discouraging to see in states – such those with extensive coastal regions – where the impact of climate change is, and will continue to be, particularly problematic.



Recommendations

The primary recommendation to education policymakers is obvious: revise state science standards as far as necessary to reflect the scientific consensus on climate change. The NGSS, which are in wide use, are a good model. But as the five states with science standards that received higher grades illustrate, it is possible to improve even on the NGSS.

Policymakers should also consider integrating climate change elsewhere in the state education standards. New Jersey⁷ provides one model for doing so, recently revising its standards to encourage practically every teacher in the state's public school system to discuss climate change in appropriate educational contexts with their students.

Importantly, it will be necessary for states to follow through on their commitment to climate change education by ensuring that in-service and pre-service teachers are equipped with the content knowledge and pedagogical training to effectively present climate change in accordance with the state science standards.

The purpose of public education is to prepare today's students to flourish in the world that they will inhabit tomorrow. That includes equipping them with the knowledge they need to meet the challenges they will face in that world. Insofar as a set of state science standards fails to recognize that climate change is real, caused by human activity, serious, and soluble, it is not fit for this purpose. Students, and the rest of society, deserve better.

Grading the States

This table provides the overall grade assigned to each state based on the evaluations from this study's reviewers. It also includes average grades for how the states addressed each of the four key points on climate change and how they performed on the six focus questions. See page 3 for an explanation of these key points and focus questions. The table also indicates which states have adopted the NGSS, which have standards based on the Framework, and which have standards not based on the Framework.

Table Legend	
	= NGSS States
	= Framework States
	= Non-Framework States

⁷ "State Board of Ed OKs New Teaching Standards for Climate Change, Sex Education," NJ Spotlight, June 5, 2020, <https://www.njspotlight.com/2020/06/state-board-of-ed-oks-new-teaching-standards-for-climate-change-and-sex-education/>

See page 3 of this report for an explanation of each column heading.

	OVERALL GRADE	1. Real	2. Us	3. Bad	4. Hope	A. Helpful	B. Explicit	C. Integrated	D. Clear	E. Higher Education	F. Civic Participation
Alabama	F	F	F	D	F	F	F	F	F	F	F
Alaska	A-	B+	A-	B+	B+	A-	A-	A-	A-	A-	A-
Arizona	C	C+	C+	C	D	C-	C	C	C	C	C
Arkansas	B+	B	B	B	B+	B+	B	B+	B	B+	B+
California	B+	B	B	B	B+	B+	B	B+	B	B+	B+
Colorado	A-	A-	B+	B+	B+	B+	A-	A-	A-	A-	A-
Connecticut	B+	B	B	B	B+	B+	B	B+	B	B+	B+
Delaware	B+	B	B	B	B+	B+	B	B+	B	B+	B+
DC	B+	B	B	B	B+	B+	B	B+	B	B+	B+
Florida	D	D	D	C-	F	D	D	D	D	D	D
Georgia	F	F	F	F	D	F	F	F	D	F	F
Hawaii	B+	B	B	B	B+	B+	B	B+	B	B+	B+
Idaho	C+	B-	C	C+	C+	C+	C+	C+	C+	C+	C+
Illinois	B+	B	B	B	B+	B+	B	B+	B	B+	B+
Indiana	D	F	F	F	C-	F	F	D	D	F	F

= NGSS States

= Framework States

= Non-Framework States

See page 3 of this report for an explanation of each column heading.

	OVERALL GRADE	1. Real	2. Us	3. Bad	4. Hope	A. Helpful	B. Explicit	C. Integrated	D. Clear	E. Higher Education	F. Civic Participation
Iowa	B+	B	B	B	B+	B+	B	B+	B	B+	B+
Kansas	B+	B	B	B	B+	B+	B	B+	B	B+	B+
Kentucky	B+	B	B	B	B+	B+	B	B+	B	B+	B+
Louisiana	B	B	B-	B	B	B-	B	B	B	C+	C+
Maine	B+	B	B	B	B+	B+	B	B+	B	B+	B+
Maryland	B+	B	B	B	B+	B+	B	B+	B	B+	B+
Massachusetts	B+	A-	B+	B-	A-	B	B+	A-	A-	B+	B+
Michigan	B+	B	B	B	B+	B+	B	B+	B	B+	B+
Minnesota	B-	C+	C+	B	B+	B	B-	B-	C+	C+	C+
Mississippi	C	C	C-	C	C+	C+	C	C-	C	C	C
Missouri	C-	C-	C-	C-	D	C-	D	D	D	C-	C-
Montana	C	B-	D	C	C-	B-	B	B-	C-	C	C
Nebraska	C+	C+	C+	B-	C+	C+	C+	C+	C+	B-	B-
Nevada	B+	B	B	B	B+	B+	B	B+	B	B+	B+
New Hampshire	B+	B	B	B	B+	B+	B	B+	B	B+	B+

= NGSS States

= Framework States

= Non-Framework States

See page 3 of this report for an explanation of each column heading.

	OVERALL GRADE	1. Real	2. Us	3. Bad	4. Hope	A. Helpful	B. Explicit	C. Integrated	D. Clear	E. Higher Education	F. Civic Participation
New Jersey	B+	B	B	B	B+	B+	B	B+	B	B+	B+
New Mexico	B+	B	B	B	B+	B+	B	B+	B	B+	B+
New York	A-	B+	A-	A	A-	A-	A-	A-	B+	A-	A-
North Carolina	C-	C-	B-	C-	C-	C-	C	D	C-	C	C
North Dakota	A-	A-	A-	B+	A-	A-	A-	A-	A-	A-	A-
Ohio	D	C-	C-	C-	F	C	D	D	F	C-	C-
Oklahoma	B-	B-	B-	B	B	B-	B-	B-	B-	B	B
Oregon	B+	B	B	B	B+	B+	B	B+	B	B+	B+
Pennsylvania	F	F	F	F	F	F	F	F	F	F	F
Rhode Island	B+	B	B	B	B+	B+	B	B+	B	B+	B+
South Carolina	F	F	F	F	F	F	F	F	F	F	F
South Dakota	C-	C-	C-	C-	C-	C-	C-	C-	C-	C-	C-
Tennessee	B-	B	B	C+	B-	B	B	B	B-	B-	B-
Texas	F	F	D	F	F	F	F	F	F	F	F
Utah	C+	C	C	B	B-	C+	C+	C	C+	B-	B-

= NGSS States

= Framework States

= Non-Framework States

See page 3 of this report for an explanation of each column heading.

	OVERALL GRADE	1. Real	2. Us	3. Bad	4. Hope	A. Helpful	B. Explicit	C. Integrated	D. Clear	E. Higher Education	F. Civic Participation
Vermont	B+	B	B	B	B+	B+	B	B+	B	B+	B+
Virginia	F	F	F	F	F	F	F	F	F	F	F
Washington	B+	B	B	B	B+	B+	B	B+	B	B+	B+
West Virginia	D	C-	C-	D	D	D	C-	C-	D	D	D
Wisconsin	C-	C	C	F	C-	C-	D	C-	C+	C-	C-
Wyoming	A	A	A	A	A	A-	A	A-	A	A	A

States at a Glance

Following are summaries of the review evaluations for each state.

NGSS States

B+

Twenty states plus the District of Columbia use the Next Generation Science Standards for their state science standards.

- **Arkansas**
- **California**
- **Connecticut**
- **Delaware**
- **District of Columbia**
- **Hawaii**
- **Illinois**
- **Iowa**
- **Kansas**
- **Kentucky**
- **Maine**
- **Maryland**
- **Michigan**
- **Nevada**
- **New Hampshire**
- **New Jersey**
- **New Mexico**
- **Oregon**
- **Rhode Island**
- **Vermont**
- **Washington**

The Next Generation Science Standards received a B+ grade on addressing climate change. NGSS earned good marks overall for addressing the reality of, the human responsibility for, and the severity of the problem of climate change. The standards got relatively higher marks on how well they address possible solutions to the problem and for preparing students for study about the issue in higher education and for responsible participation in civic deliberation about it.

Even so, reviewers noted some weaknesses, with one regretting that the standards failed to provide a stronger “connection between climate change impacts and what we can do in terms of energy and sustainability to mitigate against these risks.” Another dinged the standards for ambiguous language: “The NGSS standards frame human activities as a ‘major factor’ in Earth’s warming. This is an equivocating and inaccurate frame that allows for the insertion of ‘debate’ on what other factors may be contributing.” A third reviewer, while seeing NGSS as setting a “high bar” overall, wished that the NGSS had done a better job at helping students “recognize willful attempts to misrepresent climate data, e.g. ‘cherry-picking’ data.”



Other States

Of the remaining 30 states, 24 have science standards based on the National Research Council's *A Framework for K–12 Science Education*. Six did not use the Framework as a guide.

Alabama: F

Framework

Alabama is one of six states earning a grade of F overall. Reviewers found the state's treatment of climate change abysmal across the board, with one noting that the language regarding climate change was, at best, "tentative." One complained that the standards simply "downplay the reality, significance, human causes, and immediacy of climate change." Another: "The [standards do] not address the science of climate change. The concept that climate change is anthropogenic is absent. The concept that it poses serious risk is also absent." Two reviewers were unimpressed with token references to critical thinking, one observing that they were "not complex, explicit or well-developed." Not surprisingly, the state got failing marks from the reviewers on whether its standards will prepare students for study of the issue in higher education and for responsible participation in civic deliberation about it.

Alaska: A-

Framework

Alaska, where fossil fuel extraction makes up a significant part of the state economy, earned an A- for its coverage of climate change. Just five states received an A or A-. The state's treatment of the reality and severity of the problem was above average, and its acknowledgment of human activity as the cause was superior compared to most states. The standards got generally solid marks from two of the reviewers for addressing solutions to the climate crisis. Moreover, reviewers gave superior marks to the state's standards on key aspects such as explicitness and preparation for further study of climate change in higher education and responsible participation in civic deliberation on the issue. One reviewer: "Alaska's standards show how a state can build on the collective efforts of multiple other states and nongovernmental agencies resulting in the

NGSS and then modify, combine, and otherwise adapt those standards to meet the needs of its teachers and students. Their efforts have resulted in a strong, well-integrated, and effective set of science education standards."

Arizona: C

Framework

Arizona received a C grade, though it should be noted that this state (and North Carolina) received (on average) the widest divergence in scores from the reviewers. The state got weak marks overall for its treatment of the reality, cause and severity of climate change, but its treatment of solutions to the climate crisis was even worse. One of the more critical reviewers summarized the state's approach this way: "Arizona's standards bear the hallmarks of a tension between educators and curriculum planners who want to teach science relevant to their students and powerful interests who want to point to wording that seems to embrace teaching climate change ... but not really admit to the reality of climate change, especially in a state exposed seriously to climate change like Arizona. The teachers and their students did not come out on top of that tension." However, another reviewer noted some explicit references to climate change and the human impact on it. Overall, reviewers didn't see Arizona's standards as doing a good job preparing students for study of climate change in higher education or responsible participation in civic deliberation on the issue.

Colorado: A-

Framework

Colorado was one of five states that earned an A- or A. The state got superior marks for addressing the reality of climate change and above average scores for addressing the human responsibility for, severity of and solutions for the problem. One reviewer noted: "These are

detailed, explicit, and well-organized standards that are exploring climate science domains here with detail and nuance.” Another noted the state standards align very closely to the NGSS: “My only concern for both (NGSS and Colorado) is that the NGSS are somewhat dated; we know much more about the seriousness of climate change now than when the effort began to produce the NGSS. In particular, we need formal, K-12, science standards that address how and why some groups might want to ‘cherry-pick’ and otherwise misrepresent data about climate change or other areas as, for example, the tobacco industry has done in the past.” The state’s scores were lowered somewhat by concerns of the third reviewer: “Many of the standards are straight from NGSS, which is better than other states, but finding a clear connection between the seriousness of the problem and hope to solve it is seriously lacking.” Overall, the reviewers gave high marks to the standards for preparing students for studying climate change in higher education and for responsible participation in civic deliberation on the issue.

Florida: D **Non-Framework**

Florida, one of six states that wrote standards not based on the Framework, received a D. The state got very low marks on addressing the reality of and human responsibility for climate change and failing marks on addressing possible solutions to the problem. One reviewer put it this way: “How can students and teachers hope if there is no connection to how bad the problem is? Specifically, for the state of Florida, sea level rise and hurricanes should at the very least be discussed.” Another noted the effort to suggest that there are “alternative” explanations on the problem of climate change: “There are a few, scattered mentions of climate change throughout, but these are almost always paired with expectations to ‘consider alternative explanations’ in a manner not seen with other benchmarks where, historically, testing of alternative explanations led to breakthroughs, e.g. the chemical nature of genes (Hershey-Chase, 1952) or the mechanism of DNA replication (Meselson-Stahl, 1958).” The state

got awful marks on preparing students for study of climate change in higher education and for responsible participation in civic deliberation on the issue.

Georgia: F **Framework**

Georgia was one of six states earning an F from reviewers, with failing marks almost across the board – on the reality, cause and severity of climate change. Only on addressing possible solutions did the standards perform slightly better, but the score there was still very low. Reviewer comments paint a bleak picture, including: “A skilled teacher who already knows and wants to address climate change can do so with Georgia’s standards. An inexperienced one or one confronting climate denial will have a hard time knowing how to.... With Georgia’s challenges from sea level rise (not even mentioned in the standards), this is most unfortunate.” Another: “These standards fail to deliver organized, detailed, and robust curriculum expectations to meet the four rubrics. Particularly, the standards are not applying a coherent and explicit curriculum plan to help students build core competencies around these concepts, and the [standards are] delivering a piecemeal set of critical thinking and analysis skills here.” Reviewers gave the state failing marks on preparing students for study of climate change in higher education and for responsible participation in civic deliberation on the issue.

Idaho: C+ **Framework**

Idaho’s overall grade came to a C+. The state’s standards got their highest but mostly mediocre marks for addressing the reality of climate change, but they do a poor job of making clear the human responsibility in causing the problem. One reviewer noted: “Idaho’s standards derive largely (and often verbatim) from the NGSS with some subtle but telling edits, the net effect of which is to reduce the impact of the standards with respect to the reality, anthropogenic causes, and seriousness of climate change in them.” How the standards address the severity of the problem and possible solutions fell in between the scores in the first two categories, with one

reviewer bemoaning “a lack of opportunities for students to practice solution-oriented critical thinking.” Another: “No mention of how we can come out of this with a hopeful viewpoint, because the seriousness is downplayed.” One reviewer saw Idaho as “another example of a state that largely adopted the NGSS … and then made edits that have the net effect of downplaying the reality, seriousness, and anthropogenic causes of climate change. I suspect this resulted not from doubt by standards writers about the science of climate change but, rather, as a response to political pressure or (as is common in standards writing efforts, fear of political pressure).” Reviewers overall judged the standards as weak in preparing students for study of climate change in higher education and for responsible participation in civic deliberation on the issue. It should be noted that Idaho plans to revise its standards in 2021.

Indiana: D Framework

Indiana earned a D, just barely escaping an overall failing grade. The state’s approach to the reality and severity of climate change as well as the human responsibility for causing it is abysmal. One reviewer: “I must say [the standards do] not meet the needs of Indiana students in the process of learning their foundational understanding of the world they are inheriting and the promising careers and opportunities available to them; this is a disservice to them.” Saving the state from an F were somewhat better – but still poor – marks for addressing the possibility of solutions to the problem, which is odd since the standards failed to make clear that the problem exists. One reviewer summed up thus: “These standards do a relatively poor job in meeting the four rubrics. They do not have a coherent learning progression or explicit information. Interestingly, there is a good deal of focus on science and engineering solution-oriented perspectives, and this is why I scored the ‘there’s hope’ section higher. This … focus could be very effective if it was used to address and ideate climate adaptation and mitigation solutions.” Not surprisingly, the state got failing grades

for preparing students for studying climate change in higher education and for responsible participation in civic deliberation on the issue.

Louisiana: B Framework

Louisiana received a B. The state got relatively good scores for addressing the reality of, seriousness of, and hope for solutions to the problem of climate change. One reviewer noted: “For the Earth science and environmental science [sections], it is clear climate change is acknowledged as real and closely mirrors the NGSS standards.” The state got a somewhat lower score in addressing the human responsibility for climate change: “The anthropogenic component is there, [but it] just needs to be clearer.” Despite the B grade, however, the reviewers appeared less optimistic that the state standards prepare students sufficiently for study of climate change in higher education and for responsible participation in deliberation on the issue.

Massachusetts: B+ Framework

Massachusetts earned a B+. The state’s standards probably would have received an A- if reviewers had thought that they more clearly addressed the severity of the problem of climate change as well as the human responsibility for it. Even so, the state got superior marks for its treatment of the reality of climate change and for addressing solutions to the problem. One reviewer’s summation: “These state standards are doing a good job preparing students across the rubric. There is a coherent learning progression as well. The core concepts are covered with sufficient detail and evidence, and there are further learning appendices that include ‘further learning’ that include forward-looking, solution-oriented expertise. I would [have] like[d] the [standards] to be more explicit about the seriousness of climate impacts.” The state earned above average, but not the highest, marks for preparing students for further study of climate change in higher education and responsible participation in civic deliberation on the issue.

Minnesota: B-

Framework

Minnesota earned a B- from the reviewers. The state got weak marks for its treatment of the reality of climate change and human responsibility for it, but it got decent and above average scores for acknowledging the severity of the problem as well as possible solutions. One reviewer appreciated a standard that discussed engineering solutions to rising sea levels and noted another that “mentioned how to communicate with local Indian tribes about regional climate change and how it affects certain types of trees, etc. in the area, which I found to be very refreshing and incredibly culturally inclusive.” Another reviewer had a more negative appraisal overall: “These standards lack details, explicit language and learning progression, and detailed earth, climate, and anthropogenic forcing content. These standards are vague, unclear, and lacking structure and organized progression.” Minnesota’s standards got mediocre scores on explicitness and weaker scores on preparing students for future study and responsible participation in civic deliberation on the issue.

Mississippi: C

Framework

Mississippi earned a C from reviewers, with weak scores on its treatment of the reality, cause, and severity of climate change, though marginally better marks on helping students understand that there are solutions to the problem. Reviewers criticized “tentative” language throughout. One: “If the [the standards support] equivocation about the anthropogenic origins of climate change, how can [they] take the nature of the problem seriously? [They] can’t.” And: “The standards are incoherent and not fact-based and seem to be written with opposing viewpoints fighting out individual worded points. It’s very strange. Climate change is narrated as a ‘global challenge,’ but students are also supported in building a debate-narrative about the anthropogenic causation of climate change.” The state received poor marks on preparing students for future study and responsible participation in civic deliberation on the issue.

Missouri: C-

Framework

Missouri earned a C- from reviewers, with very poor scores on its treatment of the reality of, cause of, and severity of climate change. One reviewer: “Most of Missouri’s performance expectations and their clarification statements are identical to those of NGSS as intended by the NGSS developers. Subtle edits … , especially deletions, however, have the effect of reducing or even eliminating NGSS’s treatment of climate change (and evolution, for that matter).” The state does a particularly bad job of helping students understand that there are possible solutions to the problem: “Having edited NGSS in such a way as to reduce its treatment of climate change and its seriousness, Missouri is left with little opportunity to discuss hope (or career opportunities related to that hope) about dealing with climate change. This is a lost opportunity.” The state got awful marks on aspects such as explicitness and very poor scores on Preparing students for future study and responsible participation in civic deliberation on the issue.

Montana: C

Framework

Montana earned a C, with middling marks for addressing the reality of climate change but scoring much lower on its treatment of human responsibility for the problem. The state also rated poorly on addressing the severity of the problem as well as possible solutions. “No place within the [standards] explicitly ties climate change to human activity,” one reviewer noted. The reviewer continued: “The [standards] describe the climate system and the global carbon system, but [they] fail to connect the dots to anthropogenic climate, the seriousness of anthropogenic climate, or a solution-based skill set.” Another reviewer observed that the standards refer to “variations of flows of energy into and out of Earth systems and how that changes climate, but [do] not point out which types of energy (fossil fuel[s]) are contributing to the changing of our climate so quickly.” The state rated poorly in preparing students for future study or responsible civic participation in deliberation on the issue.

Nebraska: C+

Framework

Nebraska earned a C+, with weak scores on addressing the reality of climate change, the human responsibility for it, and possible solutions. The state's standards did slightly better in addressing the severity of the problem. One reviewer noted subtle changes Nebraska made to the NGSS "to reduce, even eliminate, the role of humans in causing climate change": "A common device used in Nebraska's standards is to adopt an NGSS standard but then change discussion of some action that 'reduces impacts of human activities on... (e.g. natural systems, [NGSS])' to action that 'increases positive impacts of human activities on... (e.g. natural systems, [Nebraska]).' This is a very subtle edit, but it precludes the possibility that human activities have negative impacts on natural systems." Still, one of the three reviewers gave the state positive marks, particularly for its discussion of possible solutions: "Nice example of a forward-looking solution-oriented skillset for building a 'there's hope' mindset." The standards got mediocre marks for preparing students for study of climate change in higher education and for responsible participation in civic deliberation on the issue.

New York: A-

Framework

New York was one of five states earning an A- or A. The state's standards received superior marks almost across the board, although reviewers indicated that the standards were less explicit than they would have preferred in discussing the reality of climate change and human responsibility for it. One writes: "New York's standards mirror the NGSS standards. No explicit connection between knowledge that climate change is happening and caused by humans and what should be done about that on a broad scale societally. However, the standards cover more than other states." The reviewers gave superior marks to the standards for preparing students for study of climate change in higher education and for responsible participation in civic deliberation on the issue.

North Carolina: C-

Non-Framework

North Carolina, one of six states that wrote standards not based on the Framework, received a C-, although it should be noted that this state and Arizona received (on average) the widest divergence in scores from the reviewers. The state's standards got especially poor marks for addressing the reality and severity of climate change and possible solutions to the problem, but (on average) somewhat better (though still mediocre) marks in addressing the human responsibility for it. In a comment similar to one made for a number of other states, a reviewer pointed out a missed opportunity: "Having downplayed or otherwise ignored climate change, its significance, and its human causes, there's no need or even opportunity to point out to North Carolina students that not only is there hope, but [also] some very meaningful and potentially rewarding career opportunities in mitigating climate change, e.g. smart grid technologies, design of more efficient transportation and housing options, installation, maintenance, and optimization of renewable energy infrastructure." The state does a poor job preparing students for study of climate change in higher education and for responsible participation in civic deliberation on the issue.

North Dakota: A-

Framework

North Dakota, a state in which mining and the fossil fuel industry are economically important, is one of five states to receive an A- or A, with superior marks almost across the board. The score on the severity of the problem dipped slightly but still was above average. The state appears to have largely stuck to the NGSS, although with what one reviewer called "subtle tweaking" here and there. One reviewer: "The standards are still strong, but they could be stronger." Another raised concerns about the need to make human responsibility for climate change clearer. Even so, the state got superior marks for preparing students for study of climate change in higher education and for responsible participation in civic deliberation on the issue.

Ohio: D

Non-Framework

Ohio, one of six states that wrote standards not based on the Framework, received a D. The state earned poor grades on addressing the reality of climate change, human responsibility for it, and the severity of the problem. But the standards got a failing grade on addressing possible solutions. "Climate change appears addressed in high school Life Sciences and Environmental Science," one reviewer noted. "But the standards, especially for high school science courses, are skeletal." The same reviewer noted that the state's Model Curriculum (the evaluation of which was outside the scope of this study) does a better job on the issue. The state received low scores on preparing students for study of climate change in higher education and for responsible participation in civic deliberation on it.

Oklahoma: B-

Framework

Oklahoma received a B-, with mostly mediocre scores across the board, although slightly better for addressing the severity of climate change and possible solutions. One reviewer: "Oklahoma's (draft) standards adopt the format, style (including color scheme), and very often the exact same wording as the NGSS. Subtle editorial changes – especially deletions – however, have the net effect of de-emphasizing NGSS's clarity regarding climate change." The state received decent scores on preparing students for future study and for responsible participation in civic deliberation on the issue.

Pennsylvania: F

Non-Framework

Pennsylvania, one of six states that wrote standards not based on the Framework, got the lowest average numerical score of all of the states and finished with an F. A likely factor in this grade is that the state's standards are nearly two decades old. "They don't acknowledge climate change at all," one reviewer wrote. "There are some places where skilled, experienced teachers could argue that a specific standard could include discussion of climate change, but

that would be very tentative at best." Another: "This state's standards perform abysmally [on climate change]. The [standards do] not address the presence or reality of climate change in any form." Perhaps needless to say, the state gets failing marks for preparing students for study of climate change in higher education and for responsible participation in civic deliberation on the issue. Note: Pennsylvania was beginning to revise its science standards while this review was under way.

South Carolina: F

Framework

South Carolina is one of six states to receive an F, with the state's standards getting abysmal marks in every category across the board. One reviewer detected "no urgency whatsoever. No understanding of the scope of the problem." Another: "The standards introduce climate science in an incomplete and piecemeal approach, leaving the students to come to their own conclusions." Perhaps needless to say, the standards get failing marks for preparing students for study of climate change in higher education or for responsible participation in civic deliberation about the issue. It should be noted that South Carolina was beginning to revise its science standards while this review was under way.

South Dakota: C-

Framework

South Dakota earned a C-. In contrast to the superior marks for neighboring North Dakota's standards, South Dakota's get very poor marks across the board. One reviewer noted policymakers' stunning decision, made explicit in the standards document, to abandon a serious effort to address climate change (or evolution), instead largely leaving the issue to parents. Another similarly objected: "The fact that South Dakota had to put a disclaimer at the beginning of [its standards] that says climate change is controversial and should be left to parents is completely and totally irresponsible as an educating body." The standards get failing marks for preparing students for study of climate change in higher education or for responsible participation in civic deliberation about the issue.

Tennessee: B-

Framework

Tennessee received a B-, with (on average) relatively stronger marks for addressing the reality of and human responsibility for climate change and much weaker marks for addressing the severity of the problem as well as possible solutions. One reviewer: "Tennessee's K-12 science content standards parallel the NGSS only in the broadest terms. Having said that, they generally do a pretty good job of focusing on the same major concepts for inclusion in K-12 science curricula. In the area of climate change causes and impacts, however, Tennessee falls far short of the clarity in NGSS. Given that the NGSS are becoming dated and much more insight into the reality, severity, and human cause of climate change now exists, the Tennessee standards fall even further short." Another noted that the standards partly address the core issues "but lack specificity and explicit language and skill building. The standards promote argumentation and debate, which is a concerning frame for building content expertise and critical thinking skills about science." The state got only weak marks for preparing students for future study and for responsible participation in civic deliberation on the issue.

Texas: F

Non-Framework

Texas, one of six states with standards not based on the Framework, is also one of six states that got an F. Only in addressing the human impact on climate change did the standards receive a non-failing grade (barely). One reviewer called the standards "vastly overspecific," with an abundance of detail on a variety of topics that crowds out opportunities to address climate change: "It's death by a thousand specialized details." Another reviewer noted that the standards provide "tacit acknowledgment that climate change is a real feature of the global planetary system" but otherwise largely ignore the issue. The state earned a failing grade on preparing students for study of climate change in higher education and for responsible participation in civic deliberation on it. Note: Texas is in the process of revising its science standards.

Utah: C+

Framework

Utah received a C+, with its weakest marks for addressing the reality of and human responsibility for climate change. On average, the state does better on treating the severity of the problem as well as addressing possible solutions. Even so, impressions from the reviewers were rather mixed. One noted limited coverage of the issue overall: "These ... segments are brief and not super explicit, but they are better than nothing. And there are nice 'solution-oriented' standards in the [biology] section asking students to think critically about how to use data to build solutions." A more critical reviewer noted that the state's standards bear only "superficial similarity to the NGSS performance expectations": "Utah's standards have been masterfully edited or otherwise changed to downplay if not ignore the reality, human cause, and seriousness of climate change." On average, the state got only mediocre marks on preparing students for study of climate change in higher education and for responsible participation in civic deliberation on it.

Virginia: F

Non-Framework

Virginia, one of six states that wrote standards not based on the Framework, is also one of six states that got an F. The state's standards got abysmal scores across the board. One reviewer noted: "I find it discouraging that a coastal state, facing increased risk of hurricanes and sea level rise, does not appear motivated to teach its children about the current and future threats of climate change – and the solutions to those issues." Where climate change might be addressed, the standards are vague and misleading: "Humanity's impact is downplayed in the standards and is obfuscated by saying 'natural' causes of climate change and 'chemicals' being released into the environment without stating what chemicals those are." The state got failing marks on preparing students for future study and for responsible participation in civic deliberation on the issue.

West Virginia: D

Framework

West Virginia received a D. The state's standards earned very poor marks on addressing the reality of climate change and human responsibility for it, but even lower marks on how they address the severity of the problem as well as possible solutions. Reviewers noted sometimes subtle changes to specific NGSS standards that distort understanding of the issue. In one case, for example, a standard changed the NGSS wording about a rise in global temperatures to, instead, a "change" in temperatures. The same reviewer noted a standard that requires students to "debate" the evidence regarding climate change: "Debate is not a normal method of science.... For what it's worth, there is no debate among climate scientists about the reality of human-caused climate change. Debating in K-12 science standards is a classic device employed by deniers (of evolution or climate change) to get their positions presented in public schools absent any (non-cherry-picked) data. Tellingly, this is the only place in the West Virginia standards that employs debate." Another reviewer: "Overall, West Virginia does not understand how serious the issue of climate change is and conceals the true cause by relying on casting doubt on humanity's impact. [H]aving students debate whether climate change is occurring is wholly unnecessary at this point in human history. A solutions-focused engineering design curriculum that focuses on solving global climate change may prove to be a better use of time for teachers and students." Not surprisingly, the state received very low marks on preparing students for future study of climate change in higher education and responsible participation in civic deliberation on the issue.

Wisconsin: C-

Framework

Wisconsin received a C-, with generally low scores across the board but a failing grade on addressing the severity of the problem of climate change. The state also got awful marks for lack of explicitness in discussing the issue. One reviewer: "The [standards support] critical and technical thinking about the climate system but [fail] at being explicit in the assessment of

climate change actually happening. [They are] missing vital content, despite being complex or organized in other domains of Earth science education." Another: "Having weakened any discussion of the anthropogenic role in climate change, there is no opportunity to emphasize the seriousness of climate change." The standards get poor marks on preparing students for study of climate change in higher education and for responsible participation in civic deliberation on the issue.

Wyoming: A

Framework

Wyoming is the only state to receive a solid A. The state earned high marks across the board. One reviewer: "The Wyoming standards, following the Framework document, provide ample opportunity for students to understand climate change and its causes." Perhaps surprisingly in a state where mining and fossil fuel extraction is an important part of the economy, the Wyoming standards did a superior job compared to other states in addressing the human responsibility in causing climate change. One reviewer: "The connection between human activity and climate change is there and is connected. Some aspects are missing, but better than some states." Another summed up: "The knowledge and skills expected of teachers and students is perhaps slightly clearer in Wyoming's standards than NGSS standards even though it is obvious Wyoming used NGSS as a base.... Wyoming incorporates and makes clear cross-cutting concepts of engineering design and technology literacy important to tackle the climate change crisis." The state got excellent marks on preparing students for study of climate change in higher education and responsible participation in civic deliberation on the issue.

Appendix A: Reviewers

The National Center for Science Education and the Texas Freedom Network Education Fund recruited three specialists to review the science standards from NGSS and states across the country. The three brought different and complementary areas of specialization and experience to the project.

Sarah Myhre is a climate scientist, researcher, and environmental justice activist in Washington state. Dr. Myhre, who earned her doctorate in ecology from the University of California at Davis, was one of 151 young scientists selected as Kavli Fellows by the National Academy of Sciences in 2018. She has published numerous peer-reviewed articles largely on paleoecology and paleoceanography. She is also the founder and executive director of the Rowan Institute, a nonprofit focused on climate change leadership.

Steve Rissing is a professor emeritus in the Department of Evolution, Ecology and Organismal Biology at Ohio State University. A specialist in ant evolution and ecology, Dr. Rissing has also been actively involved in efforts to improve public understanding of science, including by conducting research on evolution education in higher education, through a regular column in the *Columbus Dispatch*, and by serving on state science standards-related projects in Arizona and Ohio.

Casey Williams is a former high school science teacher who earned a doctorate in educational psychology from Texas Tech University, where he studied under Katharine Hayhoe, director of the Climate Science Center at the university. His dissertation examined the barriers teachers face when considering how to address climate change in the classroom. Dr. Williams currently is an education researcher at the University of Kansas.



Appendix B: Methodology

For each state, reviewers were asked to examine the middle school science standards and then high school standards for biology, chemistry, physics, earth sciences, and environmental sciences. These are the standards for courses in which climate change is most likely to be discussed and which students are most likely to take. Elementary school standards and standards for more specialized areas of science – e.g., anatomy and physiology, aquatic sciences, zoology – were not considered. When there were multiple sets of standards within a grade band for the same subject – e.g., high school biology 1, high school biology 2, and AP high school biology – only the lowest set was considered.

Reviewers were first asked to perform a preliminary assessment on the NGSS (used in 20 states plus the District of Columbia) and submit their preliminary evaluations. The reviewers and staff from NCSE and TFN Education Fund then participated in a conference call to discuss their evaluations, with the goal of ensuring the comparability of their evaluations, both for the NGSS and for the remaining standards. Reviewers were free to revise their evaluations for the NGSS following the conference call. Reviewers then examined the remaining 30 sets of state science standards (in random order to avoid any order-dependent source of bias).

In their evaluations, each reviewer provided $4 \times 6 = 24$ ratings on a Likert scale, very good (i.e., helpful, explicit, integrated, clear, prepared for higher education, prepared for civic deliberation), somewhat good, somewhat bad, very bad, or not present. Reviewers were also invited to provide free-form comments on the standards' treatment of the four key points and in general. The Likert-scale ratings were converted to a numerical scale: 4.0 for very good, 2.67 for somewhat good, 1.33 for somewhat bad, 0 for very bad or not present.

A weighted average was then taken, so that the closer that the reviewers came to maximal disagreement on an item, the less their scores for that item influenced the overall average, and the closer that the reviewers came to maximal agreement on an item, the more their scores for that item influenced the overall average. The effect of the weighting is thus to emphasize areas of agreement and de-emphasize areas of disagreement among the reviewers. The effect was slight: the correlation between the raw and weighted scores was 0.99.

The result was 24 numerical grades between 0 and 4 inclusive (ranging from 0.00 to 3.34, mean 1.49, standard deviation 1.06). Letter grades were then assigned on a curve: A to states at or over 1.67 standard deviations above the mean, A- to states at or over 1.33 standard deviations above the mean, etc.; states below one standard deviation below the mean received Fs.

Numerical grades between 0 and 4 inclusive were also calculated for the four topics (it's real, it's us, it's bad, there's hope) and the six aspects (helpfulness to students, explicitness, integration, clarity, preparation for higher education, preparation for civic engagement), using the same weighting scheme. The effect of the weighting was slight, with the correlation between the raw and weighted scores greater than 0.90 in all cases. Letter grades were then assigned on the same curve.

Details of the weighting scheme: where r_{ij} is the j th reviewer's numerical ranking for the i th item, the weighted overall average of n item rankings was calculated as follows:

$$\sum_{i=1}^n ((\text{mean}(r_{i1}, r_{i2}, r_{i3}) \times (2.309401 - \text{stdev}(r_{i1}, r_{i2}, r_{i3}))) / \sum_{k=1}^n 2.309401 - \text{stdev}(r_{k1}, r_{k2}, r_{k3}))$$

Note that the constant 2.309401 is the maximum possible standard deviation for three items between 0 and 4 inclusive. Note also that the weighted overall average would be undefined if the denominator were 0. This would occur only in cases of maximal disagreement for every item under consideration; there were no such cases.