Support for the NGSS in A Natural Approach to Chemistry

This third edition of A Natural Approach to Chemistry has been revised and updated to provide dedicated support to the Next Generation Science Standards (NGSS, https://www.nextgenscience.org/). The performance expectations for chemistry can be found in the "Physical Sciences" where they are combined with the performance expectations for physics. Unlike the high school biology and earth sciences which provide sufficient depth and breadth for a full year's instruction, the chemistry-oriented standards, mostly dealing with the periodic table, matter, and energy, do not provide enough content for a full year; and a scope and sequence driven solely by the NGSS would likely omit traditional content such as the Gas Laws, stoichiometry, some electrochemistry, organic chemistry and more. Therefore, the approach the authors have taken in this new edition is to provide support for the NGSS where they exist, to incorporate the use of phenomena and three dimensional teaching and learning throughout the program , and to include these traditional topics in order to support a full year course in chemistry at the high school level, as it is currently taught in much of the country.

Each chapter of the student book begins with an overview that sets out the anchor phenomena and provides teachers with suggestions for incorporating student questions and ends with "Chemistry Connections" used to reinforce the cross-cutting concepts (CCC) associated with the PEs addressed. Sections of the student book provide support for the disciplinary core ideas (DCIs), while the more than 60 lab investigations provide support for the practices of science and engineering (SEP) and new open-ended labs have been added to give students practice in designing solutions to engineering problems (ETS). Of course, these three-dimensional elements are woven throughout the program, not confined to these specific locations in the course.

The following table provides an overview of the NGSS support, by chapter. More detail is provided in the individual chapter sections that follow in this Teacher's Edition.

NAC CHAPTER	NGSS SUPPORT				
	PE(s)	DCI	SEP	CCC	CC ELA/MATH
1	HS-PS3-2	PS3.A	Developing and using models	Energy and matter	SL.11-12.5 MP.2 MP.4
2	HS-PS1-1 HS-PS1-3	PS1.A, PS1.B	Developing and using models	Patterns	WHST.9-12.2 WHST.9-12.5 HSN-Q.A.1 HSN-Q.A.1
3	HS-PS3-2, HS-PS3-4	PS3.A, PS3.B	Developing and using models	Energy and matter, Patterns	RST.11-12.1 SL.11-12.7 WHST.11-12.8 MP.2 MP.4
4	HS-PS1-1, HS-PS1-2	PS1.A, PS1.B	Developing and using models	Energy and matter, Patterns	RST.9-10.7 WHST.9-12.2 WHST.9-12.5 HSN-Q.A.1 HSN-Q.A.3
5	HS-PS1-1 HS-PS-4-3	PS1.A, PS4.B	Developing and using models	Patterns	RST.9-10.7 RST.9-10.8 RST.11-12.1 RST.11-12.8 MP.2 HSA-SSE.A.1 HSA-SSE.B.3 HSA.CED.A.4

NAC CHAPTER	NGSS SUPPORT				
	PE(s)	DCI	SEP	CCC	CC ELA/MATH
6	HS-PS1-1, HS-PS1-2	PS1.A	Developing and using models	Patterns	RST.9-10.7 WHST.9-12.2 WHST.9-12.5 HSN-Q.A.1 HSN-Q.A.3
7	HS-PS1-1, HS-PS1-2	PS1.A, PS1.B	Constructing and revising explanations, Developing and using models	Patterns	RST.9-10.7 WHST.9-12.2 WHST.9-12.5 HSN-Q.A.1 HSN-Q.A.3
8	HS-PS1-3	PS1.A, PS1.B	Planning and conducting investigations	Patterns	RST.11-12.1 WHST.9-12.7 WHST.11-12.8 HSN-Q.A.1 HSN-Q.A.3
9	HS-PS3-2	PS1.B, PS3.A	Developing and using models	Energy and matter	SL.11-12.5 MP.2 MP.4
10	HS-PS1-7	PS1.B	Using mathematics and computational thinking	Energy and matter	MP.2 HSN-Q.A.1 HSN-Q.A.2 HSN-Q.A.3
11	HS-PS1-7 (11.1 only)	PS1.B	Using mathematics and computational thinking	Energy and matter	MP.2 HSN-Q.A.1 HSN-Q.A.2 HSN-Q.A.3
12	HS-PS1-4, HS-PS1-5, HS-PS1-6	PS1.A, PS1.B, ETS1.C	Constructing and revising explanation, Developing and using models	Energy and Matter, Patterns	RST.11-12.1 WHST.9-12.2 SL.11-12.5 WHST.9-12.7 HSN-Q.A.1 HSN-Q.A.2 HSN-Q.A.3 MP.2
13	HS-PS1-2 (13.4 only)	PS1.A	Constructing and revising explanations	Patterns	WHST.9-12.2 WHST.9-12.5 HSN-Q.A.1 HSN-Q.A.3
14	Content from this chapter is not explicitly referenced in NGSS				
15	HS-PS3-3 (15.4 only)	PS3.B	Designing solutions	Energy and matter	WHST.9-12.7 MP.2 MP.4 HSN-Q.A.1 HSN-Q.A.2 HSN-Q.A.3

NAC CHAPTER	NGSS SUPPORT				
	PE(s)	DCI	SEP	CCC	CC ELA/MATH
16	HS-PS1-3 (16.2 and 16.3 only)	PS1.A	Planning and conducting investigations	Patterns	RST.11-12.1 WHST.9-12.7 WHST.11-12.8 HSN-Q.A.1 HSN-Q.A.3
17	Content from this chapter is not explicitly referenced in NGSS				
18	Content from this chapter is not explicitly referenced in NGSS				
19	Content from this chapter is not explicitly referenced in NGSS				
20	HS-PS1-8	PS1.C	Developing and using models	Energy and matter	MP.4 HSN-Q.A.1 HSN-Q.A.2 HSN-Q.A.3
21	Content from this chapter is not explicitly referenced in NGSS				

Use of phenomena in A Natural Approach to Chemistry

A phenomenon is simply an observable event that we can use our science knowledge to explain or predict. Engineers design solutions to problems that arise from phenomena. Phenomena provide context for the work of both scientists and engineers. Student inquiry can be driven by using a carefully chosen phenomena. Phenomena add relevance to the science classroom showing students science in their own world. A good phenomenon is observable, interesting, complex, and aligned to the appropriate standard. Use of phenomena helps students identify answers for "why they need to learn this," and shifts from learning about a topic to figuring out why something happens. The focus should not be on the phenomenon itself, but on the student generated questions that guide learning and teaching. The same phenomenon might be used in very different ways, depending on the student audience and grade level, to drive teaching and learning. Use of phenomena provides critical access for English learners or for students from historically underrepresented groups. There is a difference between anchoring phenomena, which serve as the focus for a unit, and investigative phenomena that might serve individual lessons.

Thinking about the use of phenomena has evolved since the public release of NGSS in 2013, as seen by the following table:

Early thinking about phenomena	Recent thinking about using phenomena to realize the power of NGSS
Anything students are interested in would make a good phenomenon.	Students need deep engagement with the material to generate an explanation of the phenomenon using the three elements of the PE (DCI, SEP, CCC).
Explanations are examples of phenomena.	Phenomena (e.g., sunburn, vision loss) are a specific example of a general process; they are what can be experienced or documented.
Phenomena need to be flashy, fun, or using hands on to be engaging.	Authentic engagement can occur without fun or flash; instead engagement is determined by how students create real opportunities for learning
Phenomena are just for the initial hook.	Phenomena can drive a lesson; use of a phenomena in this way drives deeper learning.
Phenomena need to be questions.	Phenomena are observable occurrences that are used to generate science questions or problems that drive learning.

Student engagement is nice but not required.	Engagement is an important access and equity issue. A good phenomenon builds on everyday experiences available to all students.
Phenomena are good to bring in after students develop the science ideas so they can apply what they learned.	Many students have trouble applying decontextualized content or ideas; anchoring the development of ideas in phenomena helps student build more usable knowledge.

Each chapter begins with an overview and with a short representation of a hands-on activity that can be used to engage students in the anchor phenomena and main themes. Students learn chemistry by doing chemistry, exploring the science and engineering practices (SEP) as they work through more than 60 lab investigations — many of which feature the Lab Hub(R), an advanced system that incorporates an RGB spectrophotometer, measures temperature and voltage, and a safe, control point heating system that eliminates the need for a bunsen burner. The Lab Hub (R) can be controlled via bluetooth connection to most smartphones, tablets, and laptops. The 5E model (add reference) is used throughout, and each chapter show a detailed treatment of every phase of the model. This is described later in this Introduction.