A GENENTECH SCIENCE EDUCATION PROGRAM

NGSS Innovations and Design Principles Feedback: Summative Review Unit 7, Lesson 7

Contents

Executive Summary

Sponsored by Genentech, Futurelab+ brought together a coalition of partners to develop an innovative, modular, 2-year biotechnology curriculum, along with instructional materials, to expose students and educators to the breadth of education and career pathways across biotechnology. To increase adoption and access to such curricula in California and beyond, the modular curriculum was designed to align with the California Career Technical Education (CTE) Model Curriculum Standards for Biotechnology, meet at least 1 year of the University of California (UC) science (D) subject requirement, and incorporate some of the three-dimensional learning innovations of the Next Generation Science Standards (NGSS). The 2-year biotechnology curriculum has four core units per year; each core unit has nine lessons and a lab that each take approximately 1 week to complete (9–10 weeks for the full unit). In total, the biotechnology curriculum has 72 lessons and eight labs that span 2 full instructional years. Because the Futurelab+ biotechnology curriculum is modular, teachers can select specific units and materials to design biotechnology courses that are relevant and appropriate for their students and teaching environments.

As an organizational partner, the American Institutes for Research® (AIR®) provided external feedback about alignment of the curriculum to the three sets of standards to Futurelab+ curriculum developers during the formative period of the biotechnology curriculum. AIR is now providing external feedback and evidence regarding each unit of the final curriculum's alignment to each set of standards in three series of reports: CTE, UC science (D) subject requirement, and NGSS. The eight reports in the NGSS series provide feedback about aspects of NGSS in a sample of the curriculum (one lesson from each unit). Developers selected Lesson 7 (Plant Medicine Product Development) from Unit 7 (Plant to Pharmaceutical) for this report. **This review was completed on materials received May 3, 2022, and has not been updated to reflect any revisions made to materials since then.**

Of note, because the primary design element of the curriculum was alignment to CTE, AIR used the NGSS Lesson Screener (not the Educators Evaluating the Quality of Instructional Products [EQuIP] Rubric) to identify aspects of the curriculum that incorporate NGSS. The EQuIP Rubric is typically used to determine whether a unit was designed for the NGSS. **Because the curriculum was designed to align primarily to CTE standards, it was not expected that the curriculum would meet all NGSS criteria.** Nevertheless, in their current form, the materials from Unit 7, Lesson 7, **meet four lesson screener criteria** and **approach the remaining two lesson screener criteria**. AIR created the *approaching* rating to indicate where a modification to materials would increase the rating to *adequate*. NGSS criteria, ratings, and recommendations are summarized in Exhibit 1.

Exhibit 1. NGSS Criteria, Ratings, and Recommendations

	Criterion	Rating
NGSS Shifts	**A. Explaining Phenomena or Designing Solutions**	Adequate
	B. Three Dimensions	▪ DCI: Adequate ▪ SEP: Adequate ▪ CCC: Adequate Overall rating: Adequate
	C. Integrating the Three Dimensions for Instruction and Assessment	Adequate
Features of Quality Design	**D. Relevance and Authenticity**	Approaching
	E. Student Ideas	Adequate
	F. Building on Students' Prior Knowledge	Approaching

Note. DCI = disciplinary core ideas; SEP = science and engineering practices; CCC = cross-cutting concepts.

- **Criterion A: Explaining Phenomena or Designing Solutions** *(Adequate).* All activities in the lesson help students increase their understanding of the product development life cycle to address a problem in a largely student-driven way.
- **Criterion B: Three Dimensions** *(Adequate)*. Students engage in several practices and core ideas as they investigate, plan, and model a potential plant-based product. In addition, student groups are tasked with tying recommendations directly to CCCs, including scale, proportion, and quantity.
- **Criterion C: Integrating the Three Dimensions for Instruction and Assessment** *(Adequate)*. The rubric for the biotech Unit 7 challenge includes multiple practice elements and core ideas and requires students to connect their recommendations explicitly to the CCC of patterns.
- **Criterion D: Relevance and Authenticity** *(Approaching)*. Students engage in the product development life cycle by developing a plant-based product from discovery through production. Working in teams, students assume the role of either corporate relations professionals, product and supply chain management professionals, or biochemists as they collaborate to model a plant-based medicine and plan to scale and manufacture the medicine. Although students and student teams have autonomy in how daily goals are met, questions are given to students, and there are limited opportunities for them to connect their own ideas and questions to the process or product. This may have been addressed in Lesson 6 when the full activity was introduced; however, AIR's review for this report applies to only Lesson 7.
- **Criterion E: Student Ideas** *(Adequate)*. Although the teacher provides guidance, ultimately the lesson is very student driven. Students oversee setting daily goals and tasks while making sure they meet the overall project timeline.
- **Criterion F: Building on Students' Prior Knowledge** *(Approaching)*. Materials in their current form suggest that students are applying prior learning to develop a plant-based product. However, the progression that builds on students' prior knowledge is not explicit, and there are limited opportunities for students to question or share prior knowledge.

AIR's review also included feedback regarding alignment of the lesson to three of the eight Futurelab+ guiding principles: equity, adaptability, and industry driven. Unit 7, Lesson 7 materials met all three of these guiding principles:

- ***Equity.*** Materials include several opportunities for students to engage with the material in a way that is meaningful for them. Conversations about the cultural importance of medicinal plants to indigenous peoples should be carefully scaffolded; teachers may benefit from additional readings and resources to help structure these conversations with students and identify potential sources of bias (both student and teacher).
- ***Adaptability.*** Materials appear to be adaptable to virtual, in-person, or hybrid settings; however, this assumes students have previously engaged with the websites or tools used in this lesson. Students may need a guided, in-person introduction to these digital tools.
- ***Industry Driven.*** Students engage in the product development life cycle by developing a plant-based product from discovery through production. Working in teams, students assume the role of either corporate relations professionals, product and supply chain management professionals, or biochemists as they collaborate to model a plant-based medicine and plan to scale and manufacture the medicine.

Methodology

Released in 2013, the NGSS were developed by a consortium of states, teacher associations, and nonprofit organizations. The purposes of NGSS are to (1) combat ignorance of science, (2) create common teaching standards, and (3) develop greater interest in science among students so that more students choose to major in science or technology. The focus on the purposes requires changes in how science is taught and the materials used to teach science. These changes, or innovations, shift the focus of science instruction from an abstract recall of facts to students demonstrating proficiency by engaging in scientific practices.

Three dimensions are integrated into the NGSS and throughout NGSS-aligned materials: SEPs, CCCs, and DCIs.

Methods

The 2-year biotechnology curriculum consists of four core units each year. Each core unit has nine lessons and a lab. As is typical with NGSS-aligned lessons, a lesson consists of more than one class period of instruction to allow students the opportunity to develop their knowledge and understanding more fully. Lessons and labs take approximately five 45-minute instructional periods to complete. In its entirety, the biotechnology curriculum has 72 lessons and eight labs and covers 2 instructional years.

AIR was asked to provide feedback and evidence of incorporation of some of the three-dimensional learning innovations common to the NGSS on a sample of the biotechnology curriculum. **Because the curriculum was designed to align primarily to CTE standards, it was not expected that the curriculum would meet all NGSS criteria.**

In addition, there are significant similarities between the innovations measured by the NGSS Lesson Screener and the University of California (UC) science (D) subject requirement, as shown in Exhibit 2. For this reason, AIR selected to use the NGSS Lesson Screener for supporting evidence of three-dimensional learning.

Exhibit 2. Similarities Between UC Science Requirements and Measured Innovations

There are significant similarities between the UC science (D) subject requirement and the NGSS Lesson Screener criteria. Specific course content guidelines of the A–G Policy Resource Guide are briefly summarized here, with notations about which Lesson Screener criteria include the same or similar requirements.

- Explicitly integrate the eight NGSS SEPs (Lesson Screener Criteria B and C); this requirement is mentioned multiple times.
- Draw content generally from the NGSS (Lesson Screener Criteria B and C) and Common Core State Standards for Literacy in History/Social Studies, Science, and Technical Subjects.
- Provide opportunities for students to participate in all phases of the scientific process and require students to discuss ideas with other students (Lesson Screener Criteria B, C, D, and E).
- Be explicit about formative and summative assessment practices (Lesson Screener Criteria B, C, and E).
- Include real-world problems that engage all students in science learning (Lesson Screener Criteria A, D, and E).
- Specify minimum mathematics course requirements.
- Reserve at least 20% of class time for teacher-supervised, hands-on laboratory activities.
- Incorporate technology (to the extent possible) to increase access and computer-based skills for students.

NGSS Lesson Screener

The NGSS Lesson Screener, developed by Achieve in collaboration with the National Science Teaching Association, is a framework for collecting evidence on (1) whether a lesson being developed or revised is on the right track for incorporating NGSS innovations, (2) if a lesson warrants further review using the EQuIP Rubric, and (3) to what extent a group of reviewers have a common understanding of the NGSS or of designing lessons for the NGSS. Because these materials were designed primarily to align to CTE standards, with aspects of NGSS and three-dimensional learning incorporated, using the Lesson Screener was more appropriate than using the EQuIP Rubric.

The NGSS Lesson Screener includes six criteria (labeled A–F). The first three Lesson Screener criteria (A–C) consider evidence of three NGSS shifts: (A) Explaining Phenomena or Designing Solutions, (B) Three Dimensions (of learning), and (C) Integrating the Three Dimensions for Instruction and Assessment. The last three NGSS criteria (D–F) consider features of quality design: (D) Relevance and Authenticity, (E) Student Ideas, and (F) Building on Students' Prior Knowledge.

Each screener criterion lists several indicators that help determine the extent to which a lesson incorporates an innovation. In other words, these indicators, or descriptions, denote whether the lesson materials meet a criterion. **A rating of *adequate* or higher means that the lesson meets the criterion.**

Possible criterion ratings on the NGSS Lesson Screener include the following:

- None (no evidence to meet the criterion)
- Inadequate (limited evidence to meet the criterion or direct evidence that the materials are not aligned)
- Adequate (enough evidence to meet the criterion)
- Extensive (more than enough evidence to meet the criterion)

For this curriculum review, AIR added an *approaching* rating to the NGSS criterion ratings. This new rating indicates where a modification to materials would increase the rating to *adequate*.

Sampling

To complete the series of NGSS Lesson Screener reviews, AIR sampled one lesson in each of the eight core units for a total of eight NGSS alignment and evidence reviews. **AIR randomly selected four of the lessons; the other four lessons were re-reviews of materials AIR reviewed during the formative review process.** Developers selected Lesson 7 (Plant Medicine Product Development) from Unit 7 (Plant to Pharmaceutical).

Two AIR staff independently and then collaboratively reviewed Unit 7, Lesson 7, to provide impartial evidence of where in the lesson and to what extent NGSS innovations are incorporated. After each AIR reviewer independently completed the review and provided a rationale for the ratings on each indicator, the team met to arrive at a final rating for each criterion (see Exhibit 3).

Exhibit 3. Lesson Review Process

Following the Lesson Screener standard review protocol, the AIR review team

- individually reviewed the lesson to record criterion-based evidence,
- individually made suggestions for improvement,
- collaboratively discussed findings to make a final rating determination, and
- summarized findings into a report.

Feedback and Evidence: Unit 7, Lesson 7

AIR found evidence that Unit 7, Lesson 7 materials meet four of the six NGSS criteria identified by the Lesson Screener and are approaching the remaining two criteria. All six criteria and evidence supporting AIR's ratings are discussed in detail in this section (see summary in Exhibit 1).

NGSS Ratings and Evidence

Rating for Criterion A: Explaining Phenomena or Designing Solutions: ***Adequate***

Lesson 7 is a collaborative, student-driven design project in which student sub-teams work to develop a model of how a plant compound interacts with cell structures to treat a human disease or condition, a communication strategy describing a target audience and communication format, and a benefit sharing agreement that honors the contributions of key stakeholders. All activities in the lesson help students increase their understanding of the product development life cycle to address a problem in a largely student-driven way. Students work to develop an understanding of how to design and scale the production of a plant-derived pharmaceutical, how to identify patient populations and ensure access to affordable medicine, and how to ethically collaborate with Indigenous communities impacted by the extraction of natural resources.

The lesson materials achieve the *adequate* rating for this criterion because they include examples of opportunities and support for students designing solutions, as evidenced by the following activities:

- **Day 1 Activities.** The lesson begins with students referencing the Project Team Process Journal in their Student Guide to review the product development cycle and determine the sub-team that they will join (Teacher Section, p. 6).
- **Days 2–5 Activities.** Students assume the role of biochemists, corporate relations professionals, or manufacturing and supply chain management professionals to collaboratively complete products representing key parts of the product development life cycle (Teacher Section, pp. 7–16).

Rating for Criterion B: Three Dimensions: ***Adequate***

The reviewers found that the materials provide opportunities to build understanding of grade-appropriate elements in **all three dimensions**. Specifically, students engage in several practices and core ideas as they investigate, plan, and model a potential plant-based product. In addition, student groups are tasked with tying their recommendations directly to CCCs, including scale, proportion, and quantity and patterns.

The following bulleted evidence supports the *approaching* rating for this criterion because the lesson materials include examples of opportunities and support for students explicitly developing their understanding of elements of both SEPs and DCIs:

SEPs, including:

- **Asking Questions and Defining Problems.** Define a design problem that can be solved through the development of an object, tool, process, or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions. Students identify how their proposed plant medicine would increase the quality of life of treated individuals as well as the benefits and potential or known side effects associated with their plant compound (Student Section, p. 16).
- **Developing and Using Models.** Develop a model to describe unobservable mechanisms. Students create a detailed system model that includes both a prototype sketch and a two- or

three-dimensional engineering prototype that specifically demonstrates their plant-based medicine's mechanism of action (Student Section, p. 37).

DCIs, including:

- **LS1-2.** Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level (Teacher Section, p. 17).

CCCs, including:

- **Patterns.** Students are expected to give and receive feedback about patterns they used to identify a patient population (Student Section, p. 38).
- **Systems and System Models.** Students are expected to give and receive feedback about system models used to describe the cellular process of a particular plant medicine (Student Section, p. 38).
- **Scale, Proportion, and Quantity.** Students are expected to give and receive feedback about the scale, proportion, and quantity used to analyze which production method best suits their plant medicine (Student Section, p. 38).

Rating for Criterion C: Integrating the Three Dimensions for Instruction and Assessment: ***Approaching***

The reviewers found that the materials provide opportunities to build understanding of grade-appropriate elements in **all three dimensions**. Specifically, the rubric for the biotech Unit 7 challenge includes multiple practice elements and core ideas and requires students to connect their recommendations explicitly to the CCC of patterns. The following bulleted evidence supports the *approaching* rating for this criterion because the lesson materials include examples of opportunities and support for students to explicitly demonstrate their understanding of elements of both SEPs and DCIs.

SEPs, including:

- **Asking Questions and Defining Problems.** Define a design problem that can be solved through the development of an object, tool, process, or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions. Students identify how their proposed plant medicine would increase the quality of life of treated individuals as well as the benefits and potential or known side effects associated with their plant compound (Student Section, p. 16).
- **Developing and Using Models.** Develop a model to describe unobservable mechanisms. Students create a detailed system model that includes both a prototype sketch and a two- or three-dimensional engineering prototype that specifically demonstrates their plant-based medicine's mechanism of action (Student Section, p. 37).

DCIs, including:

- **LS1-2.** Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level (Teacher Section, p. 17).

CCCs, including:

- **Patterns.** Students are expected to give and receive feedback about patterns they used to identify a patient population (Student Section, p. 38).
- **Systems and System Models.** Students are expected to give and receive feedback about system models used to describe the cellular process of a particular plant medicine (Student Section, p. 38).

- **Scale, Proportion, and Quantity.** Students are expected to give and receive feedback about the scale, proportion, and quantity used to analyze which production method best suits their plant medicine (Student Section, p. 38).

Rating for Criterion D: Relevance and Authenticity: ***Approaching***

Students engage in the product development life cycle by assuming the role of either corporate relations professionals, product and supply chain management professionals, or biochemists as they collaborate to develop a plant-based product through the entire development life cycle. Although students and student teams have autonomy in how daily goals are met, it is not clear where opportunities for students to relate to the process or product being development are introduced. This may have been addressed in Lesson 6 in which the full activity was introduced; however, AIR's review for this report applies only to Lesson 7.

Rating for Criterion E: Student Ideas: ***Adequate***

The reviewers found adequate evidence that the materials provide students with opportunities to share their own ideas as well as provide feedback about their peers' ideas. Students receive guidance, but ultimately the lesson is student driven.

The following bulleted evidence supports the *approaching* rating for this criterion:

- **Day 1 Activities.** Students set daily goals, tasks, and homework while making sure to meet the overall project timeline. In addition, the materials indicate Lesson 8 includes guidance "for how to modify timing for student projects that are proceeding faster or slower than expected" (Teacher Section, p. 6).

Rating for Criterion F: Building on Students' Prior Knowledge: ***Approaching***

The reviewers found inadequate evidence that the materials identify and build on students' prior learning in all three dimensions because the materials make little to no connection between expected prior learning in the CCCs and learning in the unit. The materials in their current form suggest that students are applying learning from previous lessons in this unit to develop a plant-based product. However, the progression that builds on students' prior knowledge is not explicit, and there are limited opportunities for students to question or share prior knowledge.

Futurelab+ Design Principles

Although several Futurelab+ design principles (Exhibit 4) overlap with the Lesson Screener criteria, especially concerning Principle 1 (Equity) and Principle 6 (Education Standards Aligned), AIR was asked to look for evidence of the design principles independent of NGSS. Within this section, AIR provides feedback regarding the principles of Equity, Adaptability, and Industry Driven.

Feedback about the principle of Education Standards Aligned can be surmised from the CTE alignment matrix and summary evidence reports provided for each unit.

Feedback about the principle of California Focus can be surmised from the California Subject Matter D report prepared for each unit. No formal evaluation tool was created or used to provide this feedback.

Feedback is not provided about all principles because the focus of other principles relates to the design of the materials.

Exhibit 4. Futurelab+ Principles

1. **Equity** | **Prioritize** meeting the needs of the most **underserved students** using socially responsible language.
2. **Adaptability** | Empower and equip teachers and students to **seamlessly move between virtual and in-person learning** environments.
3. **Industry Driven** | Reflect **in-demand biotech skills** and **career-laddering opportunities.**
4. **Teacher Voice** | Informed by **teacher input** and must be **teacher-demand driven.**
5. **Teaching Breadth and Inclusivity** | Build to engage a **broad set of teachers.**
6. **Education Standards Aligned** | Demonstrate **relevance** and **validity** with educators.
7. **Open Source** | Opt for **open frameworks** over proprietary approaches.
8. **California Focus** | Prioritize **California state standards and educational contexts** as a foundation for future scaling efforts nationwide.

Equity

The materials include several opportunities for students to engage with the material in a way that is meaningful for them. Conversations about the cultural importance of medicinal plants to Indigenous peoples should be carefully scaffolded; teachers may benefit from additional readings and resources to help structure these conversations with students and identify potential sources of bias (both student and teacher).

Adaptability

The materials appear to be adaptable to virtual, in-person, or hybrid settings; however, this assumes students have engaged with the websites or tools used in this lesson prior to this lesson. Students may need a more guided, in-person introduction to these digital tools.

Industry Driven

Students engage in the product development life cycle by assuming the role of either corporate relations professionals, product and supply chain management professionals, or biochemists on a team as they collaborate to develop a plant-based product through the entire development life cycle.

Resources

Achieve & National Science Teachers Association. (2016). *NGSS lesson screener*. https://www.nextgenscience.org/screener

California Department of Education. (2007). *Career technical education framework for California public schools: Grades seven through twelve*. https://www.cde.ca.gov/ci/ct/sf/documents/cteframework.pdf

California Department of Education. (2017). *California career technical education model curriculum standards*. https://www.cde.ca.gov/ci/ct/sf/documents/healthmedical.pdf

Sacramento City Unified School District. (n.d.). *Protocols for culturally responsive learning and increased student engagement*. https://www.scusd.edu/sites/main/files/file-attachments/protocols_0.pdf?1445031253

Appendix A. Lesson Screener Criteria

	Criterion	Description
NGSS Shifts	**A. Explaining Phenomena or Designing Solutions**	The lesson focuses on supporting students to make sense of a phenomenon or design solutions to a problem.
	B. Three Dimensions	The lesson helps students develop and use multiple grade-appropriate elements of the SEPs, DCIs, and CCCs, which are deliberately selected to aid student sensemaking of phenomena or designing of solutions.
	C. Integrating the Three Dimensions for Instruction and Assessment	The lesson requires student performances that integrate elements of the SEPs, CCCs, and DCIs to make sense of phenomena or design solutions to problems, and the lesson elicits student artifacts that show direct, observable evidence of three-dimensional learning.
Features of Quality Design	**D. Relevance and Authenticity**	The lesson motivates student sensemaking or problem solving by taking advantage of student questions and prior experiences in the context of the students' homes, neighborhoods, and communities, as appropriate.
	E. Student Ideas	The lesson provides opportunities for students to express, clarify, justify, interpret, and represent their ideas (i.e., making thinking visible) and to respond to peer and teacher feedback.
	F. Building on Students' Prior Knowledge	The lesson identifies and builds on students' prior learning in all three dimensions in a way that is explicit to both the teacher and the students.

Note. DCI = disciplinary core ideas; SEP = science and engineering practices; CCC = cross-cutting concepts.

AIR®

1400 Crystal Drive, 10th Floor
Arlington, VA 22202-3289
202.403.5000

About the American Institutes for Research

Established in 1946, the American Institutes for Research® (AIR®) is a nonpartisan, not-for-profit organization that conducts behavioral and social science research and delivers technical assistance both domestically and internationally in the areas of education, health, and the workforce. AIR's work is driven by its mission to generate and use rigorous evidence that contributes to a better, more equitable world. With headquarters in Arlington, Virginia, AIR has offices across the U.S. and abroad. **For more information, visit www.air.org.**