CHAPTER

8

Understanding Sustainability

In 2015, the United Nations General Assembly proposed one of the most ambitious agendas since its formation as a world body. Entitled "Transforming Our World: The 2030 Agenda for Sustainable Development," the proposal outlined a seventeen-point plan that, if enacted properly, would dramatically improve the quality of life for all of humanity. Despite lofty targets addressing issues such as poverty, gender equality, and human trafficking, all 193 member states adopted it, committing themselves to monumental global change within a fifteen-year time frame.

While the goals themselves speak to a range of global imperatives, many of the targets and indicators of success align to topics and content encapsulated within the NGSS. Goal 14 focuses on protecting and strengthening the reliance on and biodiversity of fish-producing ocean ecosystems (LS2). Goal 12 seeks to better manage natural resource consumption by reducing production waste while promoting more sound forms of energy development (ESS3).

Biomimicry sustainability lesson resources

(bit.ly/3ikncJd)

Many aspects of the plan revolve around shifting to consumption and development practices focused on sustainability; finding balance between the often-competing needs of societal progress

and the environments which support us—topics we have explored separately in our two previous chapters focused on ecosystems and human impact. Understanding sustainability requires knowledge of both, and the belief that changes made on even an individual level can have an impact, a fact that Dr. Jane Goodall imparted when she said, "The greatest danger to our future is apathy."

Helping students understand how ES creates a pathway to understanding the importance of achieving sustainability goals like those outlined in the UN plan creates authentic ways to connect content to real and authentic work.

World's Largest Lesson
(worldslargestlesson.globalgoals.org)

UN Sustainable Development Goals
(bit.ly/3w074jQ)

Sustainability: Balancing Human and Natural Needs

Sustainability-focused projects connect student understanding of natural systems to their knowledge of human systems. Where previously the projects we have described emphasize either natural or human aspects of ES, sustainability builds upon foundational knowledge students already have and helps them convert it to assessable understanding by making them apply it to their understanding of how systems influence each other. This approach is known as systems thinking, and its importance to those who work in ES fields or focus on sustainable solutions cannot be overstated.

Environmentalist and distinguished educator David Orr is a leader in this field and said, "We continue to administer, organize, analyze, manage, and govern complex ecological systems as if they were a collection of isolated parts and not an indissoluble union of energy, water, soils, land, forest, biota, and air" (2014). The type of thinking Orr describes is essential for understanding how small shifts in one part of a system can lead to much larger changes elsewhere, and it is small shifts with big effects that are needed to address the unsustainable activities that should be the focus of ES projects that explore the sustainability theme.

It is also worth noting that although systems thinking has emerged as a Western scientific pursuit only recently, the concept of all things being related has been a part of indigenous knowledge and ways of knowing for uncountable generations.

If we want our students to develop the mindsets and routines they will need to be successful in dealing with the environmental challenges their generation must grapple with, projects that emphasize sustainability are key. Additionally, projects focused on sustainability make sense because:

- They teach and reinforce important life lessons. While they are learning and developing their understanding of NGSS content, they also learn success skills such as being a conscientious consumer, thinking of the impact that your own choices have on others, and making lifestyle choices that are environmentally responsible. These kinds of life lessons help embed social-emotional learning (SEL) into projects (a topic we will expand upon in a later chapter).

- Problems of sustainable development are complex, involving multiple systems and requiring a cross-curricular approach to problem solving. If, for example, we want to transition to more sustainable and cleaner forms of energy (HS-PS3-3), plans must consider not just the development of carbon-neutral energy sources but the impact on communities and industries that rely on fossil fuels for their livelihood, the pros and cons of one form over another (solar vs. geothermal vs. wind), and the adjustments to society that will be required. Analyzing, deconstructing, hypothesizing, critiquing, and experimenting: all hallmarks of critical thinking and all required to find solutions.

- Helping students develop their understanding of sustainability positions them better to access an important and growing sector of the job market. The Bureau of Labor Statistics predicts that over the next decade many "green jobs" such as environmental engineering, environmental specialists, hydrologists, and renewable energy engineers will grow by the thousands and all pay nearly double the median US wage.

Projects focused on sustainability connect the knowledge and skills students are developing in ES class and the real-world problems that they help to address. Teachers who are interested in putting a face on environmental work can use sustainability projects to introduce students to possible career or college pursuits through connecting them with NGOs or professionals who can act as outside experts. These kinds of connections are illustrated in Table 8.1.

Finding connections between the NGSS and sustainable solutions like the ones highlighted above is not difficult, as topics focused on sustainability are embedded throughout both the high school and middle school NGSS.

TABLE 8.1. How Sustainability Connects Students to Authentic Work

MIXED GROUP DISCUSSION	MINI-TOWN HALL	REVISION AND FINALIZING OF OPENING STATEMENT	FINAL TOWN HALL
Accumulation of waste	Patronizing restaurants with recyclable containers	HS-ESS3-3	Materials recovery specialist
Transportation-related pollution	Using active transportation methods (bike, walk, etc.)	MS-ESS3-3	City planner
Energy consumption	Installing energy efficient light bulbs	HS-ESS3-2	Energy efficiency engineer
Water consumption	Watering yard or gardens when it's cool to minimize evaporation	MS-ESS2-5	Xeriscaping specialist
Food consumption	Eating more plant-forward meals	MS-ESS3-4	Food scientist

Connections to the NGSS and ISTE Standards

One connection to the NGSS that sustainability projects make is the reinforcement of cross-cutting concepts like systems and system models, stability and change, and patterns and similarities. Detecting the effects of disruptions to ecosystems and the services they provide relies on utilizing these science concepts.

By their nature, sustainability topics focus on identifying the consequences of human activity through inquiry-based processes, and then requiring students to construct solutions to reduce these consequences. Following are several examples that illustrate this.

Middle School Examples

Sea of Plastics simulation

(dumpark.com/seas-of-plastic-infographic)

Eight million tons! That is the amount of plastic that ends up in our ocean every year, where it disrupts marine ecosystems, makes its way into the food chain, and even contributes to global warming. Students can learn more about this issue through exploring the sources of plastic waste with the help of websites like the Sea of Plastic and by taking stock of their own consumption habits. They can then explore methods of shifting personal habits and decide which are the most effective by using graphs to make long-term predictions (MS-ESS3-3: Addressing plastic pollution in our oceans).

Synthetic materials are all around us and improve our lives in numerous ways—but at a cost. Projects where students learn about how common products are produced helps them understand that things like nylon, plastic, and styrofoam all have massive environmental costs that are unsustainable. After learning about the toxic byproducts, students then research alternatives to these products that are more sustainable and perform the same function. Plastics substitutes, for example, have been created using everything from olive pits to sunflower hulls (MS-PS1-3: Synthetic byproducts).

High School Examples

Many students understand the benefits of transitioning from fossil fuels like coal, oil, and natural gas to cleaner renewable forms such as solar and wind, so why haven't we just switched? Expanding their understanding of the energy crisis by designing projects that explore energy needs, development costs, and availability as well as environmental impact helps students get a much broader understanding of why the transition to renewables is a slow process. Projects designed around having them propose an "ideal energy plan" for their area also helps them develop the science practice of engaging in arguments from evidence (HS-ESS3-2: Comparing and contrasting renewable and non-renewable energy).

UN Convention on Biodiversity

(bit.ly/3inUebs)

Preserving biodiversity so that ecosystem services that people depend on are maintained is essential to our long-term survival and efforts to enhance life on Earth. In 2020, the UN Convention on Biological Diversity released a "report card" assessing its progress in a decade-long struggle to address this issue, and the results were not encouraging. By analyzing each biodiversity target and looking at its status, students can discuss, refine, and

improve on the UN plan. By synthesizing information from case studies, such as successful efforts to increase populations of species such as the humpback whale, students can create their own "report to the general assembly" on the current status of the initiative and how they would suggest the approach change or shift to be more successful (HS-LS2-7: Preserving biodiversity).

ISTE Standards Connection

Sustainability projects also offer excellent opportunities to leverage the ISTE Standards for Students. Interacting with experts, exploring comparable solutions, and articulating messaging effectively are all essential to companies and scientists involved in the work of sustainable practices.

- Sustainable businesses are continually popping up all over the globe, each with their own technology or approach to combating the effects of human-caused environmental degradation. Leveraging opportunities to communicate with and learn from professionals authenticates classroom learning and removes the onus being on the teacher to have all the answers (7b).
- What are the best ways to address issues such as the use of non-sustainable materials in manufacturing? Is it developing alternative packaging? Improving recycling technology? Educating the public about proper disposal? Helping students analyze different solutions to the same problem expands their knowledge as well as their ability to compare and contrast solutions in order to find the best one (3d).
- The science supporting certain sustainable practices is often confusing, and the success of sustainable initiatives often depends on being able to message them in a memorable and concise way. Who can forget, "Give a hoot, don't pollute"? Allowing students to create communication campaigns for their ideas and projects is a great way to mix critical thinking with real-world processes (6c and 6d).

Project Example: Sustainable Billions

Research about the effects of COVID and its implications for our way of life going forward are already underway. Both short-term and long-term studies are being conducted in areas such as mental health, the economy, education, and more to our point, the environment. One of the first comprehensive publications on the subject landed in September of 2020. The study synthesized more than eighty

other journal articles and scientific studies that explored what COVID-19 meant for the global environment. Of particular interest was, while the study noted some negative impacts such as increased amounts of waste from PPE disposal or reduced recycling due to the closing of non-essential industries, it concluded that there were more substantial net gains to environmental health. Reduced transportation and industrial activities led to cleaner air. Reduced resource consumption led to fewer polluting byproducts and improved water quality. And reduced travel and tourism allowed ecological restoration to take place in fragile wilderness and public land areas. While these results were exciting, the authors did conclude by saying, "It is assumed that all of these environmental consequences are short-term. So, it is high time to make a proper strategy for long-term benefit, as well as sustainable environmental management" (Rume et al., 2020).

Due to the dramatic shifts in lifestyle brought on by the pandemic, endangered animals' population size is increasing, the oceans are cleaner, bee populations are rebounding, and urban air quality is better than it has been in over 60 years. Even if these gains are short-term, a generation of students across the globe have been given a glimpse of what a better, cleaner, more sustainable world can look like and, most importantly, they know that it can be achieved within their lifetime. What's left for us as educators is ensuring that students have been provided with an understanding of how sustainable practices like those outlined in this chapter can make those "short-term consequences" into long-term improvements.

Project Summary

In this project students take on the role of advisors who have been tasked with managing a multi-billion dollar trust. The eccentric billionaire who willed his entire fortune—$100 billion dollars—gave only one directive: that it be invested in such a way that it has the biggest impact on addressing environmental issues by funding sustainable initiatives. Students will begin their project by familiarizing themselves with the biggest issues facing our planet's environment. They will demonstrate their knowledge through the creation of student-led lessons and by selecting one of the issues and creating an informative infographic. With this newly developed knowledge, they will form small groups and begin to work on producing their annotated budget proposals. These presentations will outline the groups' views of how best to allocate trust dollars supported by their research and by case studies of similar work going on. The groups will present their final presentation to a board of directors, who will ask them clarifying and probing questions about their choices and priorities.

Driving Question

What sustainable practices have the greatest impact on the environmental health of our planet?

Duration: Approximately 3.5 weeks

Grade Level: Middle school (6–8)

Learning Objectives

NGSS

- I can explain with evidence how physical changes to an environment affect the populations that live there (MS-LS2-4).
- I can identify and design solutions that preserve the biodiversity and function of an ecosystem (MS-LS2-5).
- I can find evidence that supports the argument that human population increases have affected the Earth's ecosystems (MS-ESS3-4).

ISTE Standards for Students

- I can locate relevant information through effective and collaborative research (3a).
- I can develop my own solutions and ideas through understanding real-world issues (3b).
- I can state my position and support it through evidence articulated in a way that is appropriate to my purpose and my audience (6d).

Entry Event

Students read a piece of mock correspondence from the foundation they work for outlining their task. They analyze the letter using a discussion protocol such as the In-2-Out protocol to clarify their understanding as well as generate questions that they will need to answer in order to complete the project.

Fieldwork and Outdoor Connections

During Phase 2 students who select issues such as water quality, air quality, or habitat preservation could use an outdoor space as a reference or to create source material for their infographics. These same spaces could also support the creation of their final presentation.

Phase 1: Initial Research on Environmental Issues

Students will begin their project by learning about the most important and pressing environmental emergencies. Through a combination of teacher-led lessons and internet research, students will work in pairs to create a list of what they view as the most serious environmental emergencies facing the planet. The teacher can introduce them to sites such as the Stockholm Resilience Centre and the EPA to help them identify and understand the content they will encounter). Students will share and synthesize their list into one class list from which they will be assigned the topics of their lessons.

EPA Sustainability Resource Hub

(epa.gov/sustainability)

Stockholm Resilience Centre

(bit.ly/3uWFD9t)

Phase 2: Student-Led Lessons and Infographics

Students will either choose or be assigned one of the issues from the list and will form small groups focused on preparing a short lesson on their topic. They will research not just the causes of the issue and its effects on planetary health, but possible sustainable solutions that are being used to address and mitigate the issue. They will present their lesson to the teacher and another group to get feedback before it is presented to the entire class. Following the presentation of their lesson, each member of the group will demonstrate their individual knowledge by producing a summative infographic similar to the ones produced by the UN Sustainable Development Initiative (See Figure 8.1). These infographics will be drafted and refined with teacher feedback.

Figure 8.1. The 17 UN Sustainable Development Goals (un.org/sustainabledevelopment).

Phase 3: Group Formation and Initial Budgeting

Sustainable Development Goals Infographic
(bit.ly/2RrKHF4)

After they have acquired a foundational knowledge of the major environmental issues facing our planet, students will be put into their project teams. Through small group and class-wide discussions they will decide which of the issues they have identified is the most imperative. The teacher can introduce them to prioritization techniques like this one used by community health officials as a way of helping them to create an initial budget.

Phase 4: Student Support for Sustainable Practices and Presentation Planning

Prioritization Techniques
(bit.ly/2TPPl0F)

With the first pass at their budgets complete, students can engage in intergroup discussions about their findings and how their prioritized lists were translated into the formation of their budgets. Following this peer feedback, they will revise their budget by considering how different kinds of sustainable technologies, practices, or behaviors best address the issues they have prioritized. This research will help them to provide evidence of how sustainability can address and reverse major issues and connect them to NGOs and nonprofits who are engaged in the work already. Students may reach out to some of these organizations while they begin to create their presentations.

Phase 5: Final Presentations and Reflection

Groups will present their final proposal to a panel representing the fund's board of directors. The presentations will outline each group's budget proposal: how they think the money should be spent and the scientific rationale or case studies that back up their decision. Following the presentation, the panel will ask questions to probe the group's knowledge as well as provide feedback on their performance. After each group has presented, the students will write a brief reflection in which they will respond to the presentations made by the other groups, and whether any of the evidence presented by their peers impacted their own opinions.

Additional Resources

Arizona State University Sustainability Teacher Resources
(bit.ly/3CDOEJt)

Sustainable Schools Project Guide to Education for Sustainability
(bit.ly/3g9D2of)

TABLE 8.2. Student Assessment Planner

FINAL PRODUCT(S)	LEARNING TARGET / STANDARDS	FORMATIVE ASSESSMENTS	SCAFFOLDS
Student lesson and infographic	I can explain with evidence how physical changes to an environment affect the populations that live there (MS-LS2-4).	Environmental emergencies pair and class list	Class share out Teacher-created resource list Think-Pair-Share
		Student-led lesson	Teacher feedback Presentation template Rubric or checklist
		Infographic draft	Teacher feedback Examples Infographic design organizer
Group presentation	I can identify and design solutions that preserve the biodiversity and function of an ecosystem (MS-LS2-5).	Student-led lesson	Teacher feedback Presentation template Rubric or checklist
		Student budget research	Example budget Connect with outside experts Teacher-vetted resources
		Presentation practice	Rubric-based feedback Critique video examples Teacher feedback
		Intergroup budget discussion	Protocol for discussion Conversation organizer Group roles
	I can find evidence that supports the argument that human population increases have affected the Earth's ecosystems (MS-ESS3-4).	Teacher-led lesson	Video recording for replay Teacher provided notes Lesson organizer
		Student budget research	Example budget Connect with outside experts Teacher-vetted resources
		Student-led lesson	Teacher feedback Presentation template Rubric or checklist