Engineering for One Planet

Engineering for One Planet Framework:

Comprehensive Guide to Teaching Core Learning Outcomes

Powered by The Lemelson Foundation
Prepared in partnership with VentureWell™
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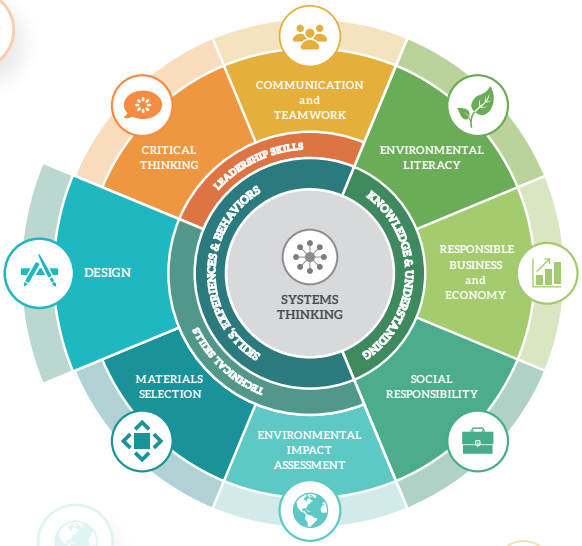
Background & Introduction



This guide serves as a companion to the Engineering for One Planet (EOP) Framework.

Purpose:

This guide is designed to minimize the activation energy needed to engage students with the EOP Framework and serve as a "how to" guide for implementation of all 46 core learning outcomes outlined in the framework.

Whether you are an experienced educator or new to teaching sustainability-related topics, the suggested activities will serve as a resource for you. We have shared learning activities and key resources for each of the core learning outcomes for the nine topics of the EOP Framework (Systems Thinking, Environmental Literacy, Responsible Business and Economy, Social Responsibility, Environmental Impact Assessment, Materials Selection, Design, Critical Thinking, Communication and Teamwork). Some examples refer to the **EOP Framework: Quickstart Activity Guide**.

For more integration examples, refer to **this chart** from our partner, VentureWell.

Please see the **EOP Framework** for an explanation of the icons used in this guide. The ABET and United Nations Sustainable Development Goals icons are explained on pages 6 and 7, and the Bloom's Taxonomy icon is explained on page 11 of the framework.

Table of Contents

Topics

Systems Thinking

Knowledge & Understanding

- Environmental Literacy
- Responsible Business and Economy
- Social Responsibility

Technical Skills

- Environmental Impact Assessment
- Materials Selection
- Design

Leadership Skills

- Critical Thinking
- Communication and Teamwork

Back to Table of Contents

Systems Thinking

Resources

- Whole System Mapping
- Inventing Green: A Toolkit for Sustainable Design
- A Safe Operating Space for Humanity
- Doughnut Economics: Seven Ways to Think Like a 21st-Century Economist
- A Healthy Economy Should Be Designed To Thrive, Not Grow
- Systems Thinking: A Cautionary Tale (Cats in Borneo)

Systems Thinking Core Learning Outcome 1 (ST.C.1)

Explain interconnectedness (e.g. intersecting, related and/or connected systems; human actions and global environmental and social impacts and consequences; synergies and rebound effects) and how all human-made designs and activities rely upon and are embedded within ecological and social systems ○ (4)

Integration Examples

Direct students to reference 1 content and videos & reference 2 pg 10 (A Systems Approach). Discuss associated examples in links above in small groups on or offline.

Refer to the Systems Thinking examples in the EOP Framework: Quickstart Activity Guide.

Systems Thinking Core Learning Outcome 2 (ST.C.2)

Identify dynamic impacts between and among different parts of the system (i.e., social, environmental, and economic considerations) ○ (4)

Integration Example

Direct students to reference 2 pg 13 (A Systems Thinking Tool - Sustainability Assessment for Innovators). Review assessment (starts pg 18). Consider the 3 phases: 1) Supply Chain, 2) Product Use, 3) End-of-Life.

Back to Table of Contents

Systems Thinking

Systems Thinking Core Learning Outcome 3 (ST.C.3)

Apply relevant concepts from required disciplines to the study of real-world problems and their solutions with empathic and ethical consideration for communities/societies, environmental justice, and cultural awareness ○ (2, 4, 7)

Integration Example

Read reference 4 (excerpts or in its entirety) and/or watch associated TED talk (reference 5). Discuss how doughnut economics is similar to and/or different than other economic systems (e.g. capitalism) in terms of environmental justice.

Systems Thinking Core Learning Outcome 4 (ST.C.4)

Create solutions that consider the scale of the activity relative to the planetary system boundaries (i.e., carrying capacities) ○ (2)

Integration Example

Read reference 3. Evaluate existing solutions for maintaining existing planetary boundaries that have not yet been exceeded and/or reversing the three planetary boundaries that have already been exceeded.

Systems Thinking Core Learning Outcome 5 (ST.C.5)

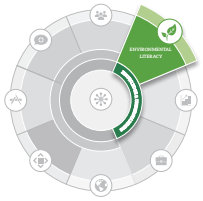
Create designs that include communities/societies, environmental ecosystems, and the life they sustain while keeping systems dynamics concepts in mind (e.g., feedback loops, complex cause-effect chains, cascading effects, inertia, tipping points, legacy, resilience, adaptation, energy systems and flows, etc.) ○ (2, 4)

Integration Example

Direct students to watch reference 6 and refer to reference 2 pg 18. Implement all or part of the assessment on an existing business as a class, small group, or individual. Discuss, present, or report out.

Back to Table of Contents

Environmental Literacy



Resources

- Earth Temperature Timeline
- Global Warming Preceded by Increasing Carbon Dioxide Concentrations During the Last Deglaciation
- A Reconstruction of Regional and Global Temperature for the Past 11,300 Years
- Circular Economy
- Millennium Ecosystem Assessment, Ecosystems and human well-being: Synthesis

Environmental Literacy Core Learning Outcome 1 (EL.C.1)

Recognize opportunities (i.e., social, economic, and environmental benefits, etc.) to solve environmental challenges ○ (2, 4)

Integration Example

Identify one or more SDGs related to environmental challenges. Discuss existing efforts to address the chosen SDG(s).

Environmental Literacy Core Learning Outcome 2 (EL.C.2)

Explain whole life-cycle and closed-loop systems thinking as related to the impact of their work (e.g., understanding of life-cycle burdens of design alternatives) ○ (4)

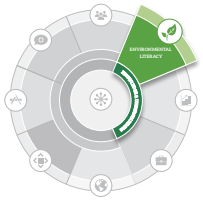
Integration Examples

Read/watch content in reference 10, discuss.

Refer to the Environmental Literacy examples in the EOP Framework: Quickstart Activity Guide.

Back to Table of Contents

Environmental Literacy



Environmental Literacy Core Learning Outcome 3 (EL.C.3)

Discuss key global ecosystem services (i.e., water, carbon, energy, and nitrogen cycles, as well as nutrient cycling, soil formation, pollination, waste decomposition, etc.) and how they are interconnected ○ (2, 4)

Integration Examples

Read/watch content in reference 12, discuss.

Read content in reference 12. Identify two ecosystem services and describe/discuss how they are interconnected.

Environmental Literacy Core Learning Outcome 4 (EL.C.4)

Explain the nature and role of energy in the world, our daily lives, and in engineering practices (e.g. is energy literate) ○ (2, 4)

Integration Example

Review the seven essential principles and fundamental concepts of energy literacy of the energy literacy framework linked in reference 36 and/or watch one or more of the videos. Discuss new or surprising insights from these resources.

Environmental Literacy Core Learning Outcome 5 (EL.C.5)

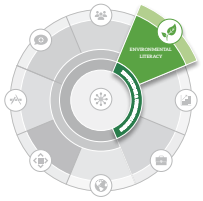
Examine data about environmental issues (e.g., climate change, energy and water use, scarcity and pollution, air quality, waste management, toxicity, etc.) including consideration for past/current/future and local/regional/global impacts ○ (2, 6)

Integration Example

Scroll through reference 7 and read linked articles reference 8 and reference 9. Discuss whether or not the illustration in reference 7 accurately represents the research presented in references 8 & 9.

Back to Table of Contents

Responsible Business and Economy



Resources

- Inventing Green: A Toolkit for Sustainable Design
- Doughnut Economics: Seven Ways to Think Like a 21st-Century Economist
- A Healthy Economy Should Be Designed to Thrive, Not Grow
- Business Sustainability Booster

Responsible Business and Economy Core Learning Outcome 1 (RBE.C.1)

Recognize opportunities and demand for more inclusive and sustainable business models, such as models that leverage product durability (e.g., renting, upgradeability, repairability, modularity, resale, etc.), protect consumers and their privacy, reflect the interests and needs of diverse users and consumers, and reflect ethical considerations ○ (4)

Integration Example

Read through the Sustainability Assessment for Innovators in reference 2. Discuss whether or not this is a comprehensive list of considerations.

Responsible Business and Economy Core Learning Outcome 2 (RBE.C.2)

Examine risks and opportunities related to changing social, economic, political, and ecological systems on their work (e.g., extended costs, value, trade-offs, partnerships, regulations, policies, etc.) ○ (2, 7)

Integration Example

Utilize the Sustainability Assessment for Innovators in reference 2 on a new or existing product.

Back to Table of Contents

Responsible Business and Economy

Responsible Business and Economy Core Learning Outcome 3 (RBE.C.3)

Demonstrate awareness that different revenue and business models can positively or negatively influence environmental and social systems as a result (e.g., shared ownership models, service models, leasing with take-back instead of asset sales for planned obsolescence; employee-owned, public-private partnerships, business-NGO collaboration models, etc.)

Integration Example

Read the content on Circular Economy in reference 10 and the linked examples and complete the exercise linked there.

Responsible Business and Economy Core Learning Outcome 4 (RBE.C.4)

Demonstrate awareness of alternative forms of capital beyond financial resources (including natural, human, social, and physical) and awareness of emerging economic systems intended to promote environmental and social responsibility in economic thinking (e.g., doughnut economics, circular economy, etc.)

Integration Example

Read reference 4 (excerpts or in its entirety) and/or watch associated TED talk reference 5. Discuss how doughnut economics is similar to and/or different than other economic systems (e.g. capitalism).

Responsible Business and Economy Core Learning Outcome 5 (RBE.C.5)

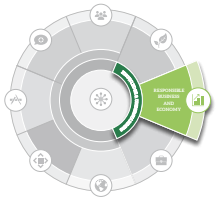
Weigh the near- and long-term costs and value of their work to the environment and society through the sustainable use of resources and engagement with stakeholders ○ (2, 5)

Integration Example

Refer to the Systems Thinking examples in the EOP Framework: Quickstart Activity Guide.

Back to Table of Contents

Social Responsibility



Resources

- The 17 GOALS | Sustainable Development
- A Healthy Economy Should Be Designed to Thrive, Not Grow
- A Brief History Of How Racism Shaped Interstate Highways
- White Men's Roads Through Black Men's Homes: Advancing Racial Equity Through Highway Reconstruction
- Stakeholder and Social Network Analysis
- Why So Few? Women in Science, Technology, Engineering, and Mathematics
- Ethical Issues with Social Impact Measurement, in Social Impact Measurement for a Sustainable Future: The Power of Aesthetics and Practical Implications

Social Responsibility Core Learning Outcome 1 (SR.C.1)

Identify the United Nations Sustainable Development Goals (SDGs) ○ (2)

Integration Example

Read through reference 13. Discuss any overlaps between the SDGs and the content or skills covered in your course.

Social Responsibility Core Learning Outcome 2 (SR.C.2)

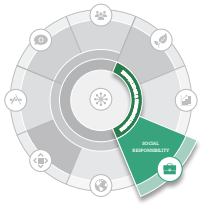
Recognize and is empathetic to ethical implications relative to social impact of their work ○ (4)

Integration Example

Read through reference 19. Discuss how collecting data to measure social impact has ethical implications.

Back to Table of Contents

Social Responsibility



Social Responsibility Core Learning Outcome 3 (SR.C.3)

Describe how engineering activities directly and indirectly cause positive and negative social/cultural impacts throughout the design life-cycle, both to workers producing the products (i.e., labor practices, livelihood, health, etc.) and to communities, society, and non-human life (i.e., resources acquisition, waste production and management, traditional/cultural methodologies, etc.) ○ (2, 4)

Integration Examples

Watch reference 5. Discuss the role engineers play in doughnut economics.

Refer to the Social Responsibility examples in the EOP Framework: Quickstart Activity Guide.

Social Responsibility Core Learning Outcome 4 (SR.C.4)

Recognize that some communities have historically been negatively impacted and/or intentionally marginalized and continue to be disproportionately negatively impacted by engineering activities ○ (2, 4)

Integration Example

Read reference 14 and/or reference 15. Discuss how engineering decision making affects marginalized communities.

Social Responsibility Core Learning Outcome 5 (SR.C.5)

Explain the role of social responsibility and environmental justice in the engineering profession (i.e., policies, laws, social justice, etc.) ○ (4)

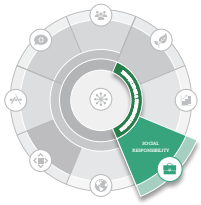
Integration Examples

Read references 14 and reference 15. Explain how the legislation described in 14 attempts to correct previous policies that impacted marginalized communities.

Read reference 18 (full or excerpts). Discuss how social science theories of motivation influence sustainability.

Back to Table of Contents

Social Responsibility



Social Responsibility Core Learning Outcome 6 (SR.C.6)

Identify cultural, local, and global implications and influences in the context of their work (e.g., cultural expressions and sensitivities, services and goods procurement, heritage site appreciation) as well as equity awareness (e.g., gender, race, ethnicity, class, etc.) ○ (2, 4)

Integration Example

Read through SDG #5 (Gender Equality) reference 13 and reference 17. Discuss the state of gender equality in engineering in your classroom, school, and/or community.

Social Responsibility Core Learning Outcome 7 (SR.C.7)

Create robust, dynamic, and resilient systems and transdisciplinary stakeholder networks ○ (2, 3, 5)

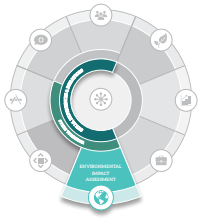
Integration Examples

Read reference 16. Discuss the steps and examples.

Read reference 16. Develop either a Stakeholder Analysis or Social Network Analysis for an issue in a local community.

Back to Table of Contents

Environmental Impact Assessment



Resources

- Life-Cycle Assessment
- Cradle to Cradle Certification
- EPEAT Certification

Environmental Impact Assessment Core Learning Outcome 1 (EIA.C.1)

Explain high-level environmental impact assessments (e.g., basic life-cycle assessments and life-cycle hazards; i.e., how they work, what information they require, how to incorporate their findings into their work) ○ (2)

Integration Examples

Review LCA content and examples in reference 11. Review Cradle to Cradle content and examples in reference 22.

Refer to the Environmental Impact Assessment examples in the EOP Framework: Quickstart Activity Guide.

Environmental Impact Assessment Core Learning Outcome 2 (EIA.C.2)

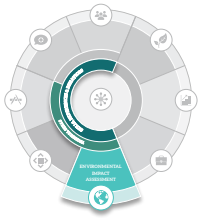
Recognize current eco-labelling systems and certificates (i.e., EPEAT, Energy Star) for sustainable production and consumption

Integration Example

Review EPEAT content and examples in reference 23.

Back to Table of Contents

Environmental Impact Assessment



Environmental Impact Assessment Core Learning Outcome 3 (EIA.C.3)

Interpret broader energy, climate, water, wastewater, air pollution, and land-use implications of their work by conducting basic environmental impact assessments (e.g., life-cycle assessments, carbon footprints, etc.) ○ (6, 7)

Integration Examples

Review LCA content and examples in reference 11. Review Cradle to Cradle content and examples in reference 22.

Review LCA content and examples in reference 11. Choose one existing LCA. Determine the area of the largest environmental impact of a given product. Describe how difficult this area would be to minimize, what the likely cost would be, and how much it could be reduced.

Create an LCA on a new product (reference content and examples in reference 11).

Environmental Impact Assessment Core Learning Outcome 4 (EIA.C.4)

Question complex or contradictory information to make decisions among trade-offs (i.e., What is the cost of the decision? Who and what will be most impacted by the decision? Are marginalized communities part of the decision?) ○ (2, 4)

Integration Example

Review LCA content and examples in reference 11. Choose one existing LCA. Determine the area of the largest environmental impact of a given product. Determine at what scale the cost of minimizing environmental impact is feasible.

Back to Table of Contents

Materials Selection

Resources

- Finding Greener Materials
- Swapping in Greener Materials
- Physical Properties of Materials, Choosing Green Materials
- How to Design for Social Impact: 4 Tips for Complex Challenges

Materials Selection Core Learning Outcome 1 (MS.C.1)

Identify potential impacts of materials (e.g. embodied energy, emissions, toxicity, etc.) through the supply chain — from raw material extraction through manufacturing, use, reuse/recycling, and end of life — with a focus on minimizing negative impacts to the planet and all people (i.e., especially those who have been intentionally marginalized) ○ (2, 4)

Integration Example

Review content in reference 24. Choose one of the resources like the Ecolizer LCA Lookup Table. Choose two different materials and discuss the realtive environmental impacts of production, processing, and recycling or waste treatment.

Materials Selection Core Learning Outcome 2 (MS.C.2)

Recognize current environmental assessment research and gaps in research ○ (6)

Integration Example

Choose one topic within environmental assessment (ex. carbon emissions). Using Google Scholar or other available library database to find 2 journal articles published within the last 3 years on the topic. Discuss the assessments.

Back to Table of Contents

Materials Selection

Materials Selection Core Learning Outcome 3 (MS.C.3)

Critique the environmental and social impacts of designs created by others) ○ (6)

Integration Examples

Read reference 27. Discuss whether or not all design has social impact.

Read reference 27. Pick an existing product, and redesign it to minimize environmental impact or improve the social impact (or both!).

Materials Selection Core Learning Outcome 4 (MS.C.4)

Compare materials properties (e.g. chemical, physical, and structural properties) and performance aligned with end-use application ○ (2)

Integration Example

Review content in reference 24 and reference 25, and watch reference 26. Choose one of the resources like the Ecolizer LCA Lookup Table. Choose two different materials and compare the material properties and performance.

Materials Selection Core Learning Outcome 5 (MS.C.5)

Design with lower impact, natural materials (e.g., earth, bamboo, agro-waste, etc.) with an aligned degree of knowledge of industrial materials (e.g., iron, steel, aluminum, etc.) ○ (2)

Integration Example

Choose an existing product (or part of one) made from an industrial material. Evaluate options for greener materials (using resources in reference 24 and reference 25) and evaluate whether a lower impact natural material could be used.

Back to Table of Contents

Materials Selection

Materials Selection Core Learning Outcome 6 (MS.C.6)

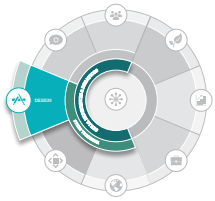
Select materials for design alternatives and trade-offs that enable a long functional lifetime, have net zero greenhouse gas emissions impact, either minimal or no environmental and social harm, or are restorative to social, cultural, and environmental ecosystems ○ (2)

Integration Examples

- List 5 natural materials and 5 industrial materials. Using resources in reference 24 and other materials databases as needed, compare and contrast one physical property of each (e.g. yield strength).
- Refer to the Materials Selection examples in the EOP Framework: Quickstart Activity Guide.

Back to Table of Contents

Design



Resources

- Introduction to Persuasive Design
- Life-Cycle Assessment

Design Core Learning Outcome 1 (D.C.1)

Execute technical analyses to choose strategies that maximize the positive and minimize the negative environmental and social impacts in order to achieve design goals ○ (2, 6)

Integration Examples

Based on an existing LCA (see reference 11 for refrigerator example) decide what the best design goal would be to minimize environmental impact.

Create an LCA on a new product (content and examples in reference 11).

Design Core Learning Outcome 2 (D.C.2)

Design for the environment and society based on discipline-specific technical skills (e.g., light-weighting, design for repairability and durability, design for upgradeability, design for disassembly, flexibility, and reuse, design for part or whole recovery, etc.) ○ (2)

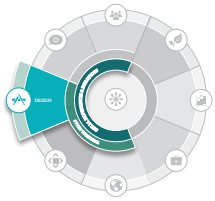
Integration Examples

Based on either a new or existing LCA, develop an improved product using one or more of the technical skills listed in the learning objective.

Refer to the Design examples in the EOP Framework: Quickstart Activity Guide.

Back to Table of Contents

Design



Design Core Learning Outcome 3 (D.C.3)

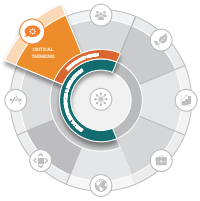
Create long-term approaches for tackling environmental problems (e.g. climate mitigation and adaptation) or preventing negative environmental and/or social impacts including creative solutions within supply chains O (6)

Integration Example

Watch reference 28. Identify an examples of creative/persuasive design in an existing product. Evaluate the effect of persuasive design on the environmental impact of that product.

Back to Table of Contents

Critical Thinking



Resources

- Changing Lifestyles
- The Role of Individual Responsibility in the Transition to Environmental Sustainability
- N. King, A Brief History Of How Racism Shaped Interstate Highways
- Critical Thinking and Sustainable Development
- Empathy, place and identity interactions for sustainability

Critical Thinking Learning Outcome 1 (CT.C.1)

Define problems comprehensively with consideration of consequences, unintended and intended ○ (1, 2, 4)

Integration Example

Read reference 14. Discuss what the intended and unintended consequences of expanding the highway system were.

Critical Thinking Learning Outcome 2 (CT.C.2)

Report being a self-aware and reflective practitioner with values, empathy, and guardianship of one's environment ○ (4)

Integration Example

Read reference 33. Discuss why empathy is important to sustainability.

Critical Thinking Learning Outcome 3 (CT.C.3)

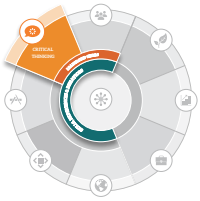
Report understanding that their values are both shaping, and being shaped, by the designs, technologies, innovations, etc., they create and scale ○ (4)

Integration Example

Read reference 32. Discuss how critical thinking on sustainable development influences values.

Back to Table of Contents

Critical Thinking



Critical Thinking Learning Outcome 4 (CT.C.4)

Recognize that every person has a role in sustainability, and has the right and need to be informed about the environmental/social/economic impacts of the products they purchase, consume, and discard ○ (4)

Integration Example

Read reference 31. Discuss individual roles in sustainability.

Critical Thinking Learning Outcome 5 (CT.C.5)

Examine norms, biases, and values that underlie one's behaviors (i.e., normative thinking and cognitive dissonance) ○ (4)

Integration Example

Refer to the Critical Thinking examples in the EOP Framework: Quickstart Activity Guide.

Critical Thinking Learning Outcome 6 (CT.C.6)

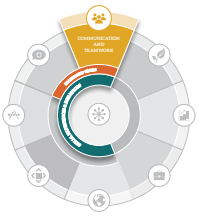
Critique complex ethical and values-based choices, employing empathy when evaluating conflicts of interest, trade-offs, and uncertain knowledge and contradictions within problem constraints ○ (4)

Integration Example

Review content in reference 30 (including videos). Evaluate the pros and cons of some kind of sustainable choice, like riding a bike. Then, determine ways to mitigate anything on the cons list.

Back to Table of Contents

Communication and Teamwork



Resources

- Comprehensive Assessment of Team Member Effectiveness (CATME)
- Leadership Tips, Tactics and Advice

Communication and Teamwork Learning Outcome 1 (CaT.C.1)

Communicate through audience-specific written, graphic/visual, oral, and interpersonal communication skills ○ (3, 5)

Integration Example

Choose one of the learning objectives above. Have students present their work either individually or in small groups.

Communication and Teamwork Learning Outcome 2 (CaT.C.2)

Develop leadership potential and capability ○ (5)

Integration Example

Take the 55 minute course in reference 35.

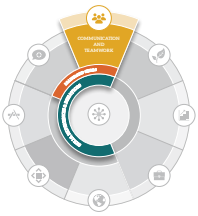
Communication and Teamwork Learning Outcome 3 (CaT.C.3)

Demonstrate ability to work within and function well on teams and across disciplines ○ (5)

Integration Example

Use the CATME Peer Evaluation in reference 34 along with a group project. Ideally you can use it early on in a project as a formative assessment, then at the end of a project as part of a summative assessment.

Back to Table of Contents



Communication and Teamwork

Communication and Teamwork Learning Outcome 4 (CaT.C.4)

Demonstrate self-awareness and understanding of unconscious bias ○ (5)

Integration Example

Refer to the Communication and Teamwork examples in the **EOP Framework: Quickstart Activity Guide**.

Communication and Teamwork Learning Outcome 5 (CaT.C.5)

Prioritize projects, schedules, and time, and manage people equitably and inclusively ○ (5)

Integration Example

Choose a learning objective and corresponding integration example above that can't be completed in one sitting. Create a schedule for completion and (if working in groups) assign sub-tasks to different team members.

Communication and Teamwork Learning Outcome 6 (CaT.C.6)

Champion sustainability-focused values and approaches (e.g., to management, procurement, marketing, etc.) to maintain the integrity of design criteria across environmental and human dimensions ○ (5)

Integration Example

Contact your local, regional, or state office of sustainability. Create a plan to ask management to partner with this organization to include sustainability-focused content in either curricular (coursework) or extra-curricular activities.

References

[1] Whole System Mapping, VentureWell. Accessed: May 11, 2021.

[2] Inventing Green: A Toolkit for Sustainable Design, VentureWell. 2017.

[3] J. Rockström et al., A Safe Operating Space for Humanity, Nature, vol. 461, no. 7263, Art. no. 7263, Sep. 2009.

[4] Doughnut Economics: Seven Ways to Think Like a 21st-Century Economist, Chelsea Green Publishing. 2017. Accessed: May 11, 2021.

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