Stage 1 – Desired Results

ESTABLISHED GOALS

- Summarize the concepts of sustainable infrastructure and industrialization and society's needs for a systemic approach to their development.
- Recognize the local, national, and global challenges and conflicts in achieving sustainability in infrastructure and industrialization.
- Define the term resilience in the context of infrastructure and spatial planning, understand key concepts such as modularity and diversity, and apply them to their local community and nationwide.
- Describe the pitfalls of unsustainable industrialization and in contrast share examples of resilient, inclusive, sustainable industrial development and the need for contingency planning.
- Name new opportunities and markets for sustainability innovation, resilient infrastructure, and industrial development. (Stapleton-Corcoran, E, 2023).

Transfer

Students will be able to independently use their learning to…

…describe the elements within the three pillars of sustainable development (environmental, social, and economic) explain the importance of minimizing Whole Life-Cycle Carbon (WLC) footprint, healthy construction practices, the using recycled/reclaimed materials, and the minimization of waste, as they participate in the Greenhouse project and in describing the benefits of the project to others.

Meaning

UNDERSTANDINGS

Students will understand that…

- Sustainable construction means sensitivity to environment impacts
- A sustainable building prioritizes protection of the environment above the users' well-being.
- Building and renovating in a sustainable way means giving a preference to local and bio-sourced materials.
- Sustainable construction means healthier materials: for those who install them on building sites, and for those who use them afterwards

ESSENTIAL QUESTIONS

- What is the role of sustainability of information and communication technology (ICT) including supply chains, waste disposal, and recycling?
- What is the relationship between quality infrastructure and the achievement of social, economic, and political goals in the community?
- How does the need for carbon-neutral infrastructure like roads, information and communication technologies, sanitation, electrical power, and water contribute to sustainable ecosystems in the community?
- How can inclusive and equitable sustainability practices promote innovation and community development?
- Why does sourcing electricity from renewable resources (solar, wind, etc.) both reduce dependence upon, as well as strengthen, local energy grids?
- Why do sustainable practices create expanded job markets, opportunities, and investments?

Acquisition

Students will know the elements of the three pillars of sustainable development:

- Environmental pillar: climate change, adaptation, and mitigation, pollution prevention and zero waste, life cycle approaches, biodiversity, disaster risk reduction.
- Social pillar: human rights, hunger and poverty eradication, security, clean

Students will be skilled at…

- Describing sustainability in conceptual terms
- Explaining the elements of an ecosystem
- Defining biodiversity
- Specifying how sustainable principles impact people in the community
- Illustrating the concept of interconnectivity in the context of sustainability
- Differentiating between linear vs circular approaches to sustainable design
- Describing the triple bottom line concept

	water and sanitation, health and well-being, reduced non-equalities (gender, income, living standard ones), decent work, social responsibility, quality education, cultural diversity, sustainable urbanization, and sustainable lifestyles. • Economic pillar: resources (raw materials, energy, water, air, land) and their efficiency, circular economy, affordable and clean energy, sustainable consumption and production, research and development (R&D), innovations and entrepreneurship of all stakeholders, and economic growth.	• Citing examples of stakeholders in sustainable projects • Describing the role of ethics as part of sustainable practices. • Showing how sustainable practices can influence corporate social responsibility.

Stage 2 – Evidence and Assessment

Evaluative Criteria	Assessment Evidence
Criteria will include standards developed for post-secondary coursework in sustainable development practices, along with collaboration and collective design skills, presentation skills, and a broad understanding of the relevance and impact of sustainable practices in the community as well as in society at large.	PERFORMANCE TASK(S): • Apply design thinking, principles, and tools • Demonstrate holistic and critical evaluation of design artifacts • Demonstrate competence in customizing a design process to meet the needs of the project and the team • Understand fundamental principles of psychology of design and human factors decisions • Apply reliability analysis in design decision making • Demonstrate analytical modeling in design decision making • Work effectively on a collaborative design project • Demonstrate individual and collaborative technical presentation skills • Develop a professional career development plan and artifacts
	OTHER EVIDENCE: Formative assessments will consist of reflective discussions on subject matter, small group projects involving the three pillars of sustainability, and exploration of sourcing of materials, impact of designs on completed structures, and the role of climate and energy sources.

Stage 3 – Learning Plan

Summary of Key Learning Events and Instruction (40 hours)

Lesson 1: Overview of Sustainability (4 hours).
The first objective is to provide students with definitions of key concepts. An ecosystem is defined as an integrated network of living things, including plants, animals, and microorganisms. These entities have specialized systems to interact with physical environments, like air, water, sun, weather, climate, and soil. We refer to the living components of an ecosystem are called biotic components, and the non-living components are called abiotic components. Visual examples are provided in the form of videos and diagrams.

A sustainable ecosystem as a self-sustaining biological system that can support life without external inputs. It meets the needs of current populations and is capable of expanding (or contracting) to interact with future populations. In addition, it has the following characteristics:

- Diversity: Maintains its characteristic diversity of major functional groups
- Productivity: Maintains its productivity through survival and procreation mechanisms
- Biogeochemical cycling: Maintains its rates of biogeochemical cycling through adaptation to changes in the environment
- Stable controls: Interactive controls, such as climate, soil, and disturbance regime, vary in a stable manner toward an equilibrium state.

The second objective relates to the Whole Life-Cycle Carbon (WLC) footprint of a structure. Greenhouse gases are emitted throughout a building's lifecycle, from the raw materials used in construction, through to the electricity used to run the building, right up until the demolition and end of life treatment of the building's materials. Whole Life Carbon is a way to describe this and can be defined as 'the combined total of embodied and operational emissions over the whole life cycle of a building'.

The third objective is to perform a lab exercise to demonstrate one or more of the above characteristics. A fourth parallel objective is to provide instruction on how to perform lab work. A typical framework for this exercise includes the following activities:

- Observe the phenomenon and formulate questions
- Conduct background research
- Formulate a hypothesis
- Design an experiment
- Collect data
- Analyze data
- Draw conclusions.

Alternatively, an agentic simulation tool such as NetLogo could be used instead of a traditional, physical lab bench to carry out this assignment.

Lesson 2: Sustainability Life-Cycle Assessments (12 hours)

Life Cycle Assessment (LCA) is a scientific method to measure the environmental footprint of a product. A typical result could include 15 or more impact outcomes. Before measuring, a prototype greenhouse design is provided to the cohort.

The first lesson objective is to think about this structure, and consider the energy usage and emissions, along with factors such as utilities, transport, materials, etc.

The second objective is to assign roles and responsibilities among the cohort. These will include

- Who needs to collect this data (a sustainability analyst title is assigned)
- What data is needed (this involves gathering information on the structure, covering, environmental, and security aspects of the greenhouse),
- Where to collect the right data (pointers to existing information from the University of Illinois Extension Service, the Chicago Architecture Center, and other resources from academia and industry. Ensure informing entities in time and give them adequate time for their data delivery).

The third objective is data collection from primary sources. It should cover raw process- and site-specific data, estimates, statistics, and bookkeeping. By creating a list of all the necessary inputs and outputs of the greenhouse's lifecycle, they are aligned to corresponding impacts when performing an LCA.

Primary data is crucial for LCA, since it makes the LCA more credible through accurate raw data that's specific the greenhouse study – instead of relying on averages. And it offers more reliable, authentic, and objective footprint insights. This enables focused and effective sustainable efforts and gives the cohort more ownership over their LCAs.

The fourth objective is to determine the measurement scope of the greenhouse lifecycle, utilize a five-phase approach:

1. Raw Material Extraction and Reclamation (concrete and aggregates for footings, lumber for structures, etc.)
2. Manufacturing & Processing (recycled PEL for covering and water reclamation)
3. Transportation (for all phases, from supplier to site – in this case the site is the Kelly Hall YMCA in Chicago).
4. Usage (forming and fitting materials using of low-emissions tools, etc.)
5. Waste Disposal (minimizing waste through thoughtful measurement and handling, identifying reuse potential, disposal of unusable remnants through reputable local agencies)

The fifth objective is to define take-out Phases. Once the greenhouse has exceeded its useful life, provision is made for its disposal. Students will evaluate two lifecycle scopes:

1. *Cradle-to-grave* includes all the 5 life phases in the measurements. *'Cradle'* is the inception of the greenhouse with the sourcing of the raw materials. '*Grave'* is the deconstruction of the greenhouse, and the disposal of its constituent parts. It shows a full footprint from start to end.
2. *Cradle-to-cradle* is a variation of *cradle-to-grave* but exchanges the *waste* stage with a recycling/upcycling process that makes it reusable for another product. This lifecycle effectively "closes the loop" and accounts for the disposal, recycling, or repurposing of all materials.

Students will learn the importance of selecting the correct model and communicating that model to their stakeholders.

The sixth objective involves finding average rates of waste treatment options (mainly: incineration, landfill, composting, or recycling) from local statistics, or possibly from specific providers who is capable of executing the waste method for the project. Collect data on:

- The exact waste-disposal method and its processes.
- The emissions connected to your waste disposal method.
- Possible energy recovery in the disposal processes.
- Possible recycling processes of (part of) the materials.

The use phase and end-of-life are essential for determining the greenhouse's ecological footprint.

Lesson 3: Introduction to Rating Systems (6 hours)

The first objective is to present students with the fundamentals of sustainable building standards and rating systems including LEED, Green Globes, BREEAM, and Green Star. These systems are the prevailing industry standards for sustainable building and are recognized worldwide as authoritative. Students will emerge with a good understand of why standards are important and how to apply them.

The second objective is to ask students to work in groups and provide an overview for each of these sustainability rating systems, and their suitability for greenhouse design and construction. Each group will focus on one of the systems. Students are expected to leverage prior knowledge, as well as to harvest findings from academia, industry, and other entities. The instructor and the subject matter experts will go around the room and provide mentoring and insight to each group.

The third objective is to ask each. group to present and submit its understanding of the system, as well as its applicability to the "cradle-to-cradle" and "cradle-to-grave" lifecycle scopes, and how the system specifies guidelines for each.

The fourth objective is for the instructor to moderate a class discussion wherein all students reflect on each other's opinions and are expected to reach mutual understanding of the term "construction rating system".

The fifth objective is for each student is asked to utilize the in-class discussion as well as citations from their research to write a brief paper on how a certain construction material or construction system that is chosen by the student can be used to promote high performance sustainable construction.

Lesson 4 – Applying LEED standards to Greenhouse Design (12 hours).

The first objective is that students are asked to create a reference guide for greenhouse construction using LEED standards. Previous experience indicates that students work most effectively and efficiently by with some prior exposure to the regulations and standards outlined by the United States Green Building Council in its LEED manual. This material was covered in Lesson 3 and is now applied in this lesson.

The second objective is to pair students to reading and understanding the 2009 USGBC LEED manual and develop the requested reference guide pertinent to greenhouse construction.

During this session, the instructor observes, guides discussions, and answers questions. Repeated questions from various groups are addressed to all class members.

The third objective is for each group to submit and make presentations pertaining to their LEED-based reference guide. The presentation findings are aggregated and collectively discussed, leading to a single version of the guide that all are aligned to.

Lesson 5 – LEED Certification (6 hours)

The first objective is for students to use the reference guide from Lesson 4 to develop a report on how to attain LEED certification for a new greenhouse construction project. This will demonstrate the importance of service learning and is expected to create enthusiasm for the emerging design and construction phases of the project, because they see their future and the future of their community given relevance through the coursework.

The second objective is to use the prototype design introduced in Lesson 2 is distributed, and students are divided into groups to analyze one or more of the major LEED credits. Each group develops a report pertaining to its assigned credit using their previously developed
reference guide, and any other required supporting material. In the analysis, the students need to show (1) which credits are attainable in light of the prototype greenhouse design; (2) which credits are not incorporated in the prototype greenhouse design but are achievable with some modifications and amendments; and (3) which credits are not obtainable regardless of any reasonable new design proposals.
The third objective is to bring all groups together and work collectively to integrate their findings into a comprehensive assessment report.
The fourth objective is for students to submit a final report, make presentations, and reflect on each other's work.

Stapleton-Corcoran, E. (2023). "Sustainability Learning Outcomes and Learning Objectives." Center for the Advancement of Teaching Excellence at the University of Illinois Chicago. Retrieved [today's date] from Sustainability Learning Outcomes and Learning Objectives | Center for the Advancement of Teaching Excellence | University of Illinois Chicago (uic.edu)